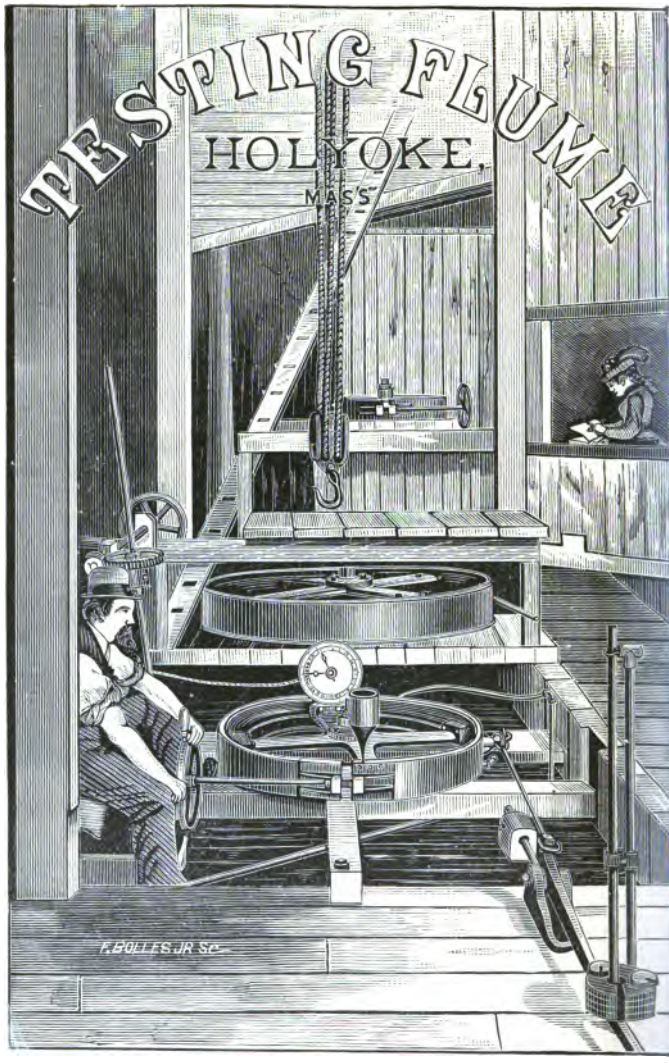
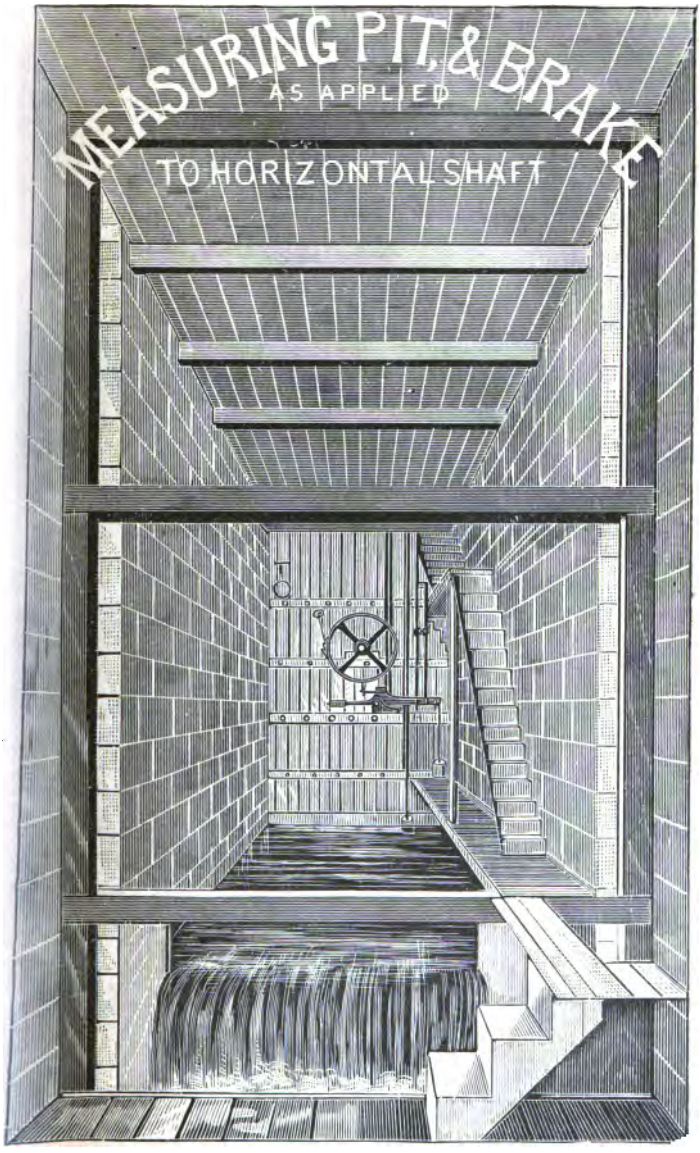

TESTING FLUME
HOLYOKE,
MASS.
F. BOLLES, JR. Sc.


MEASURING PIT, & BRAKE
AS APPLIED
TO HORIZONTAL SHAFT

HOLYOKE

Hydrodynamic Experiments,

MADE BY THE

HOLYOKE WATER POWER CO.,

HOLYOKE, MASS.,

1879-80.

SPRINGFIELD, MASS.:
WEAVER, SHIPMAN AND COMPANY, PRINTERS.
1880.

HOLYOKE

Hydrodynamic Experiments.

To make the matter generally understood, the following notice is here republished:

HOLYOKE WATER POWER COMPANY,

Holyoke, Mass., April 10, 1879.

NOTICE TO TURBINE BUILDERS AND MANUFACTURERS.

The practice of testing turbines, so common the past ten years, has undoubtedly done much towards bringing the best into use; but there has been one serious defect in the system; that is, the practice has generally been confined to the trial of small wheels, owing to the great expense that would be caused by the tests of large sizes. As it is a matter of vast importance that the best turbine plans should be established beyond chance for doubt, this Company has provided means for a thorough competitive test of the various kinds of turbines that may be offered for trial, and invite Water Power Companies, cities that pump their water supply, and all others interested in the matter, to take part therein. Each builder shall superintend the setting of his wheel—the setting and testing to be done at the expense of the Water Power Company. *Capacity of each wheel to be sufficient to discharge about 5000 cubic feet of water per minute, under 18 feet head. Each wheel will be thoroughly tested from half to whole gate, and, if deemed best, under at least two different heads; also under several feet of back water. At the conclusion of the trial, a full report will be made of the results obtained and of the workmanship, and probable durability of each kind of wheel tried. Turbine builders of this or any other country are invited to furnish wheels, and those proposing to do so should give notice of such intention as soon as possible.

Tests to commence the first day of September next.

HOLYOKE, MASS., June 2, 1879.

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*Builders who have not got patterns for wheels of so large capacity may enter their largest size, but it is better that all should discharge about the same quantity.

The parties here named have either entered wheels for the trial or have made application for information as to conditions to be observed, &c.

Swain Turbine Co., Lowell, Mass.
Houston Turbine,
Fales & Jenks, Pawtucket, R. I.
Wolf, Allentown, Pa.
Victor, Stilwell & Bierce M'fg Co.,
Dayton, Ohio.
Hercules, Holyoke Machine Co.,
Holyoke, Mass.
Henry Vandewater & Co.,
Auburn, N. Y.
Willis Reed, Danbury, Ct.
E. Dodge, Spencer, N. Y.
Edward Wemple, Fultonville, N. Y.
Joseph Hough, Mechanics Valley, Pa.
Humphrey Machine Co., Keene, N. H.
S. Sleeper, Mt. Morris, N. Y.
Knowlton & Dolan, Logansport, Ind.
National, Bristol, Conn.
Little Giant, Auburn, N. Y.
T. H. Risdon, Mt. Holly, N. J.
Rodney Hunt Machine Co.,
Orange, Mass.
W. D. King & Co., Pontiac, Mich.
N. F. Burnham, York, Pa.
Wm. F. Perry, Bridgeton, Maine.
Goldie, McCulloch & Co.,
Galt, Canada.
Gates Curtis, Ogdensburg, N. Y.

As is often the case in such trials, few of those desirous of taking advantage of the Company's offer were ready at the time named, and, as the notice did not state any time for closing, builders have been tardy in sending their wheels. The ordinary work of the testing flume has been continued during the time, so that the wheels reported are only about one-half the number tested; and any one acquainted with the matter will see that there has been no unnecessary delay in making the report.

The experiments were announced as competitive, meaning, in general utility, economy in the use of water, convenience, cost and durability.

Large turbines were called for, that their discharge might be greater than could be measured in the testing flume of any turbine builder, but this was not insisted upon, as, to have done so, would have limited the competition to a few old builders with full sets of patterns, whose wheels have often been tested and reported. Experience has not yet produced any fact that even hints that any particular size of turbine, small or large, can be made to produce higher results than any other size of the same make. Consequently, builders were allowed to send wheels the most convenient in size for themselves, and it is not known that any one of experience furnished a wheel with the expectation that it would give the highest possible results, but that its general merits should commend it to the public, and that the value of any peculiarity in its construction should be determined.

Competitive turbine tests, in the common meaning of the term, have been useful in the past, as they have enabled those interested in such matters to decide upon the most desirable plans. At the present time, however, such tests can have no public value, because each turbine tested only represents itself in efficiency. Another of

the same size and make might and probably would give quite different results, so that should each competitor have a second, third or a tenth wheel tried, his standing would be likely to change with each wheel tested. The Fourneyron, Boyden, Birkinbine and Centennial tests all prove this fact, as they also prove that the builders who have furnished the turbines that have given the highest efficiency reported, have only had a brief popularity, as manufacturers have found other turbines more desirable for business; and it will be evident from the results obtained in these experiments, that builders have taken this fact into consideration and have generally tried to produce turbines economical at any stage of gate opening, rather than to gain the highest possible efficiency at whole gate, where, in practical use, it is rarely used. And in this there has been a decided gain, as there has also in an increased capacity for a given diameter of wheel, noticeable in the Rechard as well as the Hercules and New American.

In considering the comparative merits of the wheels here reported, it should be understood that previous to 1876 turbines of any make for a given diameter generally gave about the same power. There were builders who believed in some mysterious power in *leverage*, who constructed wheels with extended diameter and proportionally small discharge, but these were exceptional; the rule held good, and it will be necessary to take this fact into consideration to realize the improvements in turbines during the past four or five years.

Turbine builders were requested to furnish draft tubes of different sizes with their wheels, that the efficiency of such tubes might be determined; and that the loss in transmission through belts and gears might also be ascertained, several well known gear-making firms were requested to furnish gears for trial.

The experiments have been conducted upon the supposition that their purpose was to ascertain the real utility of the various devices tested under the every-day ordinary conditions to which such plans are subjected in practical use, rather than possibilities in exceptional cases under the most favorable circumstances; and features of known interest developed are recorded in connection with their development. It was expected that the experiments would require much time, and as they were made in the public testing flume, it was necessary that each should be conducted as expeditiously as accuracy would permit; consequently, James Emerson, from his intimate familiarity with such matters and experience in handling wheels, was employed

to see that each turbine was set in a manner satisfactory to its builder, and to have a general supervision over the work.

Samuel Webber, Civil Engineer of Manchester, N. H., known in connection with the Centennial tests, was selected to assist in making the experiments, and reports herewith.

Theo. G. Ellis, Civil Engineer of Hartford, Conn., well known through his published works and long employment by the government in river and harbor improvements, was selected by the turbine builders to see that the experiments were skillfully and fairly conducted, whose report is appended.

For the information of the uninitiated, it is proper to state that a turbine, under a given head, does its best at a certain speed. To find this point it is necessary, in testing, to begin with a light weight, run a minute or more, then add weight and repeat until the best point is found; and the test that fixes that point is the speed at which the wheel should be geared to work, and the efficiency at that point is the efficiency of the wheel. The average efficiency from a part to whole gate means when the wheel is running at that speed at any stage of gate opening, and the efficiency at other speeds is to be considered only so far as it shows the loss that will occur through gearing above or below the proper point.

The tests are supposed to be correct and complete in each case as given, but for the information of students or others wishing to work out the data for themselves, the following is given in explanation of the statement at the head of each test: multiply revolutions by 10, 20, &c. It must be understood that during each test the scale beam is attached to the brake at a point which, if revolving, would describe a circle of 10, 15 or 20 feet in circumference. Consequently, the revolutions must be multiplied by the number given, as for example: Of the first New American wheel tested—rev. per minute, 207.5; weight, 675. $207.5 \times 15 = 3112.5 \times 675 = 2100937.5 \div 33000 = 63.66$ h. p.

To make this report really useful, it is issued in size convenient for the pocket.

WM. A. CHASE, AGENT.

ENGINEERS' REPORTS.

REPORT OF THEO. G. ELLIS.

HARTFORD, CONN., *September* 13, 1880.

WILLIAM A. CHASE, ESQ.,
Agent of the Holyoke Water Power Co.

SIR: Having been requested to take part in the interesting experiments upon turbines made by your Company in October and November, 1879, at the Holyoke testing flume, I did so with great reluctance as, owing to many professional engagements, I could not give so much time to the subject as its importance seemed to warrant, and could not possibly be at Holyoke at all times during the experiments. I finally, however, agreed to be present at part, at least, of the tests in behalf of the turbine builders, to see that the experiments were fairly conducted as far as lay in my power, and to make such observations as I thought best.

It was understood that the mechanical work of setting the wheels and making the experiments was to be superintended by James Emerson, whose previous experience in the testing of turbines at the same locality eminently fitted him for the task. The flume and apparatus used was mostly, if not entirely, designed and constructed by him, and he was familiar with all its details and capabilities. Whatever may have been his previous published views, it is believed that in the present tests all the turbines presented for trial have received the same careful attention and trial. In some cases the record does not appear to show as full and complete a trial as in others, but there was always some good reason, irrespective of any prejudices for or against that particular wheel, for the apparent limitation of the trial.

Mr. Samuel Webber, civil engineer, of Manchester, N. H., who had superintended the Centennial tests of turbines, was present during the whole of the experiments, and I availed myself of an association with him in overlooking the experiments, so that one of

us should be present at every trial, and thus always have a disinterested party to record the readings of the dynamometer and gauges, and the time of the experiment, to serve as a check upon the readings recorded by Mr. Emerson's assistant and taken by him. Mr. Webber was assisted most of the time by Mr. Stockwell Bettes, civil engineer, of Springfield, Mass., who read the gauges and otherwise checked the readings taken and recorded by Mr. Emerson.

All of Mr. Emerson's readings, and such of Mr. Webber's as he desired, were recorded in a book kept for the purpose. These records were kept and all the computations therefrom were made by Miss Charla Adams, who for a long time has been familiar with such experiments and computations as an assistant of Mr. Emerson, and who, I am satisfied from a personal examination of her work, has performed the duty in a careful, accurate and thorough manner.

Experiments upon the following wheels were all witnessed by Mr. Webber, and part of them by myself:

October	10,	1879,	Tyler Wheel.
"	11,	"	Thompson Wheel.
"	14,	"	New American Wheel.
"	15,	"	"Humming Bird" Wheel.
"	16,	"	Success Wheel.
"	17,	"	Two Tait Wheels.
"	18,	"	Repeated Test of Tait First Wheel (buckets chipped).
"	18,	"	Sherwood Wheel.
"	21,	"	Nonesuch Wheel.
"	22,	"	Curtis Wheel.
"	28,	"	Pair of Curtis Wheels set horizontally.
November	11,	"	Hercules Wheel.
"	12,	"	Hercules Wheel.
"	13,	"	Houston Wheel.
"	14,	"	Wetmore Wheel.
"	15,	"	Monarch Wheel.

The computed volumes of discharge, and the percentage of efficiency of the foregoing wheels, as shown in your Report, the proof of which has been submitted to me, have been carefully examined with a view to determine the relative value of the wheels named, and their respective performances under the different conditions and amounts of water with which they were tested.

In the testing of turbines, it has been the practice to first determine the velocity at which the wheel will give its greatest effect

when using all the water that will run through it with the gates or entrance apertures open to their full extent, or at "full gate;" then to diminish the quantity of water to three-quarters and one-half, as nearly as practicable, and to estimate the power of the wheel when running at the same velocity. The experiments at Holyoke were conducted practically in this manner. The best velocity was found for "full gate," and then the amount of water was diminished gradually in successive experiments to the neighborhood of half the quantity, with the wheel running as nearly as might be at the same speed.

This is perhaps the best way to make such tests, everything considered. But it does not in all cases give the exact relative value of the wheels. Some turbines might give a better result at a different velocity when using a less amount of water, and make their average, say, from half to full gate better than by the former method. The difficulty, however, of getting at the exact velocity at which any turbine would give its best results when using different quantities of water, is too great to warrant such determinations in a series of comparative tests such as were made at Holyoke. The same method must be established for all, and the customary one appears to be the fairest, as no other would probably be agreed to by all the turbine builders. In the practical use of turbines for power, it is rarely the case that a wheel is put in of the exact power required. A margin must be left for an excess of power to meet emergencies, and allowance must be made for an increase of machinery, so that a larger wheel is ordinarily purchased than would just suffice to meet present requirements. For this reason, it is not the wheel which gives the highest percentage of efficiency at "full gate" that is really the best wheel. There can be no point fixed at which any wheels should be compared, but it is thought that perhaps "three-quarters gate" is about the average point at which wheels are used, and their comparative efficiency at from one-half to their full power sufficiently represents their real value. It would probably be a better comparative test of wheels to get their best velocity at "three-quarters gate" and run them with the same velocity for greater and less quantities. This would give the real value of the wheel better than the present practice, but it would probably not be generally agreed to. In using the terms "full gate," "half gate," "three-quarters gate," etc., the relative quantity of water is meant. The opening of the wheel gates themselves is not considered. Their construction is often such that

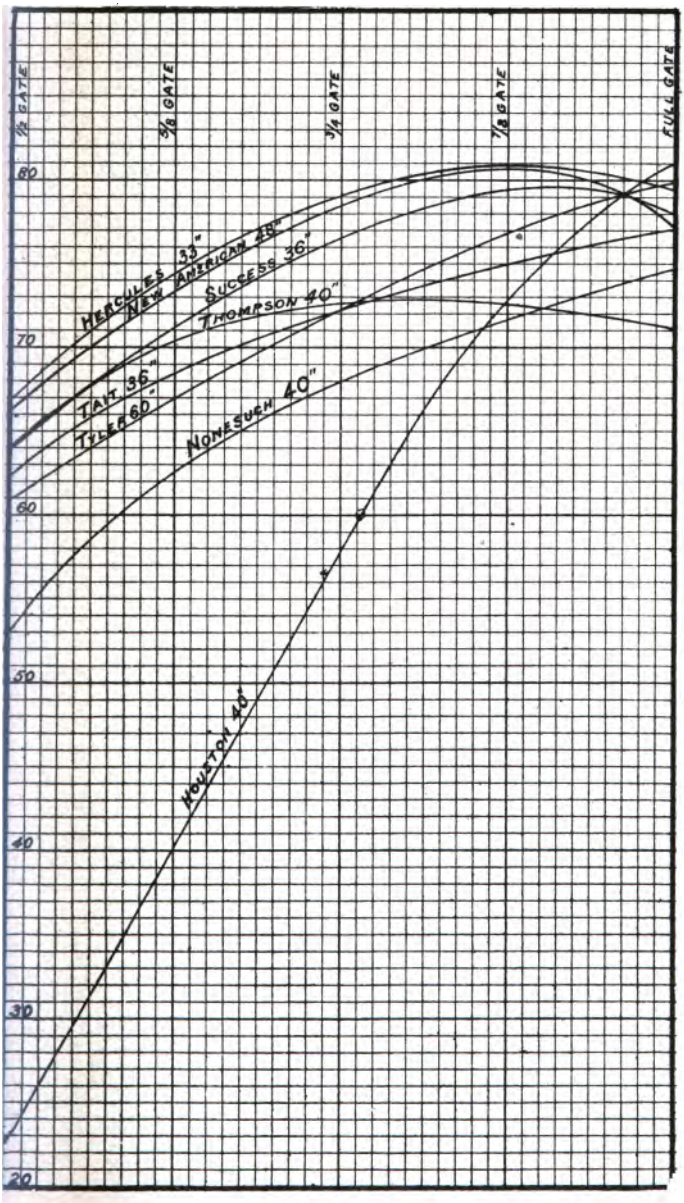
opening or closing them a certain proportion does not affect the quantity of water in the same manner. It not unfrequently happens that a slight closing of the gate increases the quantity of water passing through them, so that the gates themselves are deceptive and are no criterion of the amount of water used. The gate opening is sometimes used to deceive the uninitiated in the circulars of unscrupulous turbine builders, calling "half gate" perhaps two-thirds the whole quantity of water, so as to give a higher percentage of efficiency, but the only true standard of comparison is the actual amount of water measured as it leaves the wheel.

The experiments upon the before-named wheels have been carefully plotted with the amounts of water and the percentage of efficiency as co-ordinates, and a mean curve drawn through the points for each wheel. These curves have been all reduced to a uniform horizontal scale for the purpose of comparison, so as to obtain their relative efficiency at all proportions of the whole amount of water from half to full gate. The curves of the eight wheels giving the highest efficiency are shown on the annexed diagram. The horizontal scale shows the parts of the whole quantity of water from half to full gate, and the vertical scale shows the percentage of efficiency at all points corresponding to the amount of water indicated.

The average percentage of efficiency for these eight wheels has been computed for the amount of water from half to three-quarters gate, from half to full gate, and from three-quarters to full gate, as shown in the following table:

TABLE SHOWING AVERAGE PERCENTAGE AT PART GATE.

NAME.	½ to ¾. Per cent.	¾ to full. Per cent.	½ to full. Per cent.
Hercules,	.737	.805	·771
New American,	.732	.795	·763
Success,	.708	.786	.747
Tyler,	.665	.766	.715
Tait,	.680	.744	.712
Thompson,	.696	.721	.709
Nonesuch,	.619	.712	.666
Houston,	.397	.717	.557


½ GATE
⅜ GATE
¼ GATE
⅛ GATE
FULL GATE
80
70
60
50
40
30
20
HERCULES 33"
NEW AMERICAN 48"
SUCCESS 36"
THOMPSON 40"
TAIT 36"
TYLER 60"
NONESUCH 40"
HOULTON 40"

By examining the diagram and the foregoing table, the peculiarities of the several wheels will be readily seen. It will be observed that the Houston turbine, which has the highest percentage of effect at full gate, is really the least efficient at from half to three-quarters, and from half to full gate, of all those shown on the diagram, and is only superior to the Nonesuch at from three-quarters to full gate, and that by a very trifling amount; so that the wheel which apparently has the highest percentage is really the least desirable for actual use. The Thompson turbine, which has the lowest percentage of those shown, at full gate, rises to the sixth place at from one-half to full gate, and to the fourth place at from one-half to three-quarters gate. The Tyler turbine, which has the second highest percentage at full gate, falls to the sixth place at from one-half to three-quarters gate. The Hercules turbine, which stands third only at full gate, takes the first rank at from half to full gate, or any of its subdivisions. The New American turbine, which stands only fifth in the percentage at full gate, is second only to the Hercules at from one-half to full gate or either of its subdivisions, and, indeed, differs from the Hercules very slightly in its useful effect through the whole range shown.

Taking the average useful effect of the wheels shown from one-half to full gate as a measure of their efficiency, their relative value is in the order shown in the table.

Among the turbines tested at about the time of the experiments upon the wheels before named, were two very remarkable ones on account of their very different qualities and performance. These were the Rechard, a statement of which is included in your Report, and the Victor, which was used in the gear experiments, likewise attached to your Report. The first-mentioned has a percentage of useful effect of only 69 at full gate, while the latter has a percentage of 92. At thirteen-sixteenths of full gate, the percentage of efficiency becomes reversed, and below that the Rechard is by far the most effective turbine. From one-half to full gate the efficiency of the Rechard is second only to the Hercules, while for the same range the Victor would come fourth in the list.

Neither Mr. Webber nor myself witnessed the experiments upon these wheels, but they are mentioned to show that a high percentage at full gate is often deceptive and does not always indicate the best wheel for practical use.

In the foregoing Report, with the exception of the last two wheels, only such wheels are considered as were tested in the presence of Mr.

Webber or myself. The list appears to embrace all the really good wheels presented, and gives their efficiency as we saw it. Some of these wheels show a little higher percentage than I have given in some of the other experiments in your Report, particularly the New American, but I have thought best to confine myself to those experiments that were witnessed and verified by the attending engineers.

With the sincere hope that comparative and competitive tests of turbines will be continued, and that thereby the public and users of power will know more fully the qualities of the wheels they purchase, and the useful effect they are likely to derive from them,

I remain, very respectfully yours,

THEO. G. ELLIS, CIVIL ENGINEER.

REPORT OF SAM'L WEBBER.

WM. A. CHASE, Esq.,
Treasurer Holyoke Water Power Co.

Dear Sir: I was requested by you in October, 1879, to come to Holyoke and be present at a series of competitive tests of turbines, and to see that the measurements were correctly made, and the apparatus in perfect order. I was, accordingly, present the greater part of the time from October 9th to November 15th, and witnessed the tests of the following wheels, viz.:

Oct. 9th and	10th,	The "Tyler" Wheel.
"	11th,	" "Thompson" Wheel.
"	14th,	" "New American," being a wheel of the Swain type of bucket, with the case and gates formerly used for the "American Wheel."
October	15th,	The "Humming Bird" Wheel.
"	16th,	" "Success" Wheel.
"	17th,	" "Tait Centennial," 2 wheels.
"	18th,	" " 1st wheel repeated.
"	"	" "Sherwood" Wheel.
"	21st,	" "Nonesuch" Wheel, from Clark & Chapman.
"	22nd,	" "Gates Curtis" Wheel.
"	27th,	" " pair of wheels on draft tube.
Nov. 11th and	12th,	" "Hercules" Wheel.
"	13th,	" "Houston" Wheel.
"	14th,	" "Wetmore" Wheel.
"	15th,	" "Monarch" Wheel.

During all these tests, I verified the measurements of the weir, e revolutions of the wheel, the head of water, and the weight on e steelyard, and in these measurements I was assisted by Mr. ockwell Bettes; and from the data so obtained I have made up mplete calculations of the results.

I have examined the proof sheets sent me by Mr. James Emerson, his report and calculations of these tests, and have no hesitation accepting them, as in very many cases we agree exactly, while in

no case is there a variation of over 1 per cent., and these differences are mainly due to slight differences in the weir readings, as taken by Mr. Emerson and Mr. Bettes.

I was also present during a portion of the gear and belt tests in April, 1880, and can certify to the correctness of Mr. Emerson's report of those tests, so far as the results then obtained are concerned.

I cannot, however, consider these tests as conclusive, from the fact that the gears were entirely new, and that there was no accurate method of regulating the proper depth to which the gears should be put in contact—a slight change in such depth having shown a great difference in the net power attained.

Neither was there any method for regulating or ascertaining the the tension of the belts.

Nor should I be satisfied to accept the result obtained from the 15-inch Victor wheel as conclusive of the merits of wheels of that make, as from various tests the very small wheels of almost all patterns usually give a higher percentage than the larger ones.

Yours very truly,

SAM'L WEBBER, C. E.

REPORT OF JAMES EMERSON.

WILLIAM A. CHASE,

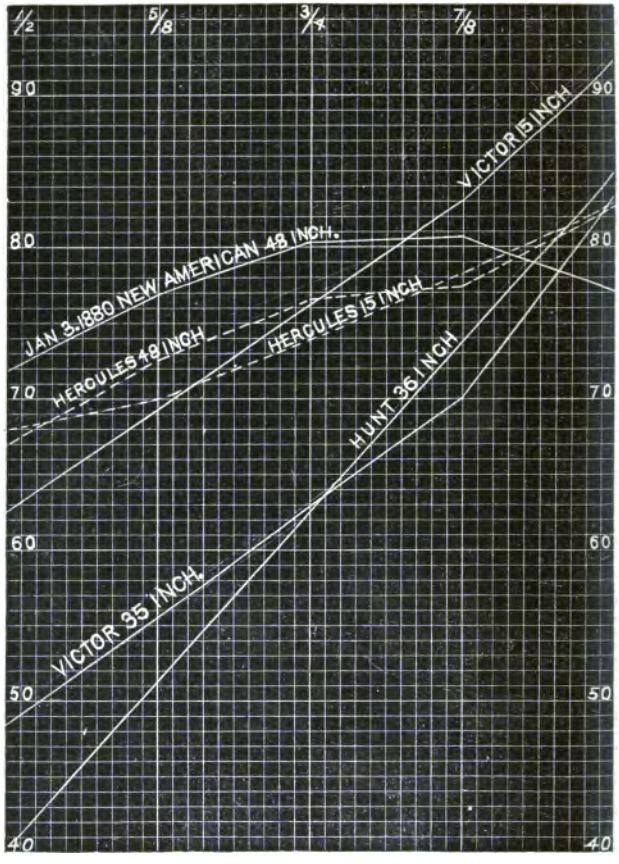
Agent Water Power Co., Holyoke, Mass.

SIR: Having, in connection with the engineers named, completed the series of turbine and dynamic experiments announced by your Company, the results obtained by myself, with accompanying remarks, are here submitted for your consideration.

In presenting this report, it is a pleasure to recall the interest taken in the experiments, from the beginning to their close, by engineers and experts in such matters. There was hardly a trial of any kind without the presence of such. Mr. Bettes assisted almost invariably; James M. Sickman, C. E. of Holyoke, often examined the arrangements; Prof. Norton, of the Sheffield Scientific School of New Haven, Ct., with members of his class, spent a day in witnessing the tests, and, later, six graduates of his class assisted in testing the 15-inch Victor. Prof. Whittaker, of the Massachusetts Institute of Technology, with some sixteen members of his class, not only witnessed the experiments, but had charge of the apparatus for several hours, and tested the 33-inch Hercules for practice. The Principal of the Holyoke High School, with a large delegation of scholars, both male and female, spent some hours in witnessing the tests, and seemingly with much pleasure. There were also witnesses from very distant places, and some that one would hardly expect would feel an interest in such matters, but they seemed to do so.

JAMES EMERSON.

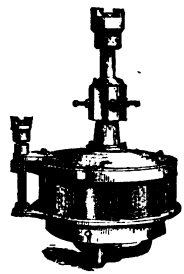
WILLIMANSETT, MASS., Aug. 1, 1880.



The above diagram shows that either wheel represented can honestly be recommended by its builder as giving high efficiency. The practical mill owner, however, should be able to select advantageously; but, to do so, he should take the fact into consideration that the best turbines of a given diameter are of much greater capacity than formerly, and that he is likely to get one too large to require whole gate. The 35-inch Victor fairly represents the average efficiency of wheels of that make.

Wemple Wheel.

Sent by Wm. Wemple's Sons, Fultonville, N. Y.



18-inch wheel. Central and downward discharge. Inside register gate.

Data below for one minute. Multiply revolutions by 10. April 17, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.30	300	000	000		
" "	18.24	150	335.3	15.24	623.06	.7265
" "	18.30	160	327.6	15.88	627.43	.7298
" "	18.40	170	319	16.43	640.98	.7375
" "	18.26	180	303.5	16.55	645.48	.7434
" "	18.40	190	296	17.04	648.48	.7561
" "	18 30	200	280	16.97	651.49	.7516
" "	18.24	210	259.5	16.51	660.44	.7257
" "	18.20	185	293	16.42	648.48	.7329
" "	18 17	195	282	16.66	651.49	.7451
Part Gate.	18.23	150	326	14.81	624.55	.6887
" "	18.20	175	296	15.69	626.04	.7290
" "	18.20	170	294.6	15.17	642.48	.6868
" "	18.21	165	282 5	14.12	599.42	.6850
" "	18.22	160	290	14.06	596.42	.6851
" "	18.24	140	278	11.79	542.63	.6306
" "	18.24	125	293.5	11.11	525.45	.6137
" "	18.34	100	259	7.85	437.65	.5178
" "	18.31	100	291.5	8.83	447.21	.5700
" "	18.43	75	227.3	5.65	330 80	.4906.
" "	18.33	75	300.5	6.83	370.86	.5302
" "	18.41	75	301	6.84	373.48	.5842
" "	18.42	80	291.5	7.07	382 69	.5309
" "	18.48	55	288.5	4.81	299.28	.4722
" "	18.48	50	303	4.59	298.03	.4412

Mr. Wemple not being able to get up a wheel of the size required in time, allowed this to be reported as a representative of the kind.

Tyler Wheel.

30-inch wheel, sent by John Tyler, Claremont, N. H.

This wheel was tested a few days before the time named for the general test, that it might be used.

This wheel was furnished for the purpose of enabling those seeking for such information to compare its power of transmission with those of the same size made by others, as the most of the popular builders have had 30-inch wheels tested. One fact, however, must be taken into consideration in making such comparisons, namely, that while the increase in the sizes of one builder is, say, 6, 12, 18, 24 and 30 h. p., the increase in another make will be 6, 9, 18, 40, 48, 75, &c., but, in the aggregate, the total power of all the sizes of each builder amount to about the same. The Tyler flume wheel represents very fairly the average capacity of the most popular turbines known previous to 1876, excepting, however, the Boyden, which, for its diameter, is far less in capacity than any of the others.

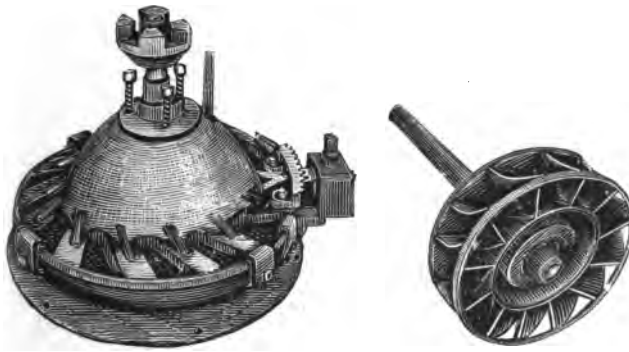
This particular wheel was made from the same patterns as the one tried at the Centennial tests, and several times at the Holyoke flume. Special pains was taken that it should be an exact duplicate of that one. The curb was the same as the Centennial, yet, as will be seen by those who have the means to make the comparison, the discharge of this wheel was one-sixth greater than the first. Mr. Tyler was so unwilling to accept the results, that he had the wheel taken out, reset, and retested on three successive days, each trial giving the same results.

Data below for one minute. Multiply revolutions by 15. Aug. 1, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	18.30	375	218	37.15	1373.63	.7831
" "	18.28	385	213.7	37 42	1373.63	.7896
" "	18.27	400	209 6	38.10	1373.63	.8045
" "	18.27	425	201.6	38.96	1386.77	.8148
" "	18.27	440	198.5	39 70	1400.00	.8225
" "	18.26	450	194	39.68	1421.11	.8103
" "	18.25	475	180	38.86	1445.03	.7809
" "	18.28	440	194.5	38.90	1418.46	.7960

Moessinger & Heathecote.

Sent by Moessinger & Heathecote, Glenrock, Pa.



20-inch wheel.

This turbine was a Jonval, with register gate, as represented above.

Data below for one minute. Multiply revolutions by 10. Sept. 3 and 4, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.40	100	320.5	10.47	511.13	.5894
" "	18.40	110	325	11.16	513.84	.6250
" "	18.40	120	330	12.00	517.92	.6668
" "	18.39	130	323.5	12.74	524.75	.6988
" "	18.39	140	310.5	13.17	531.59	.7133
" "	18.38	150	300	13.63	535.71	.7329
" "	18.38	160	281.6	13.65	541.23	.7265
" "	18.39	170	254.5	13.11	543.99	.6938
" "	18 38	180	230	12.54	545.37	.6623

The wheel bound upon the step during the above trial; and it was taken out of the flume, overhauled, then re-tested, giving the results recorded below.

Whole Gate.	18.55	150	316.6	14.39	539.08	.7618
" "	18 56	160	307.5	14.90	546.00	.7784
" "	18.53	170	300.5	15.48	551.51	.8016
" "	18.53	180	287.5	15.68	551.51	.8123
" "	18.53	190	270	15.54	555.68	.7990
Part Gate.	18.71	50	295	4.47	381.41	.3316
" "	18.65	75	296	6.72	432.22	.4414
" "	18 59	100	292	8.85	478.14	.5272
" "	18.55	125	292 5	11.08	517.17	.6114

Victor Turbine.

Stilwell & Bierce Manufacturing Co., Dayton, Ohio.

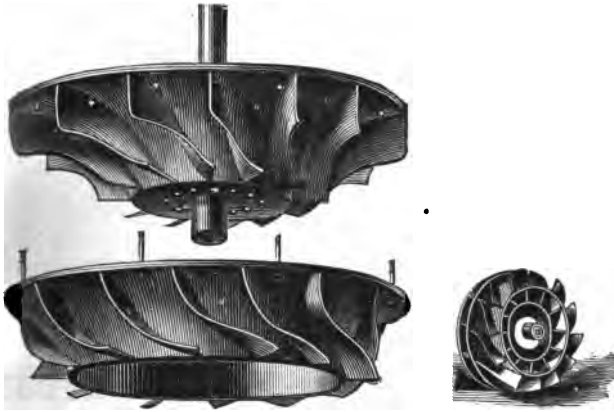
This wheel is of recent origin; discharges the water used outward, downward and centrally; has a register gate that works easily and opens in full with half a turn of gate rod. It is so designed that its buckets may be made of bronze, if desired. Its discharge in proportion to its diameter is only equaled by that of the Hercules. Price of this 35-inch wheel, $650; weight, 4500 pounds.

Data below for one minute. Multiply revolutions by 20. Sept. 5, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	16.95	2650	000	000.		.000
" "	17.18	1500	147.5	134.09	4994.79	.8289
" "	17.10	1550	141.5	132.98	4999.22	.8232
" "	17.11	1600	137.5	133.33	5012.56	.8230
" "	17.09	1650	131.5	131.50	5025 86	.8121
" "	17.07	1700	126 6	130.43	5030.31	.8048
" "	17.11	1450	150	131.81	4990.36	.8172
" "	17.11	1400	156	132.36	4972.64	.8236
" "	17.10	1475	150	134.03	4981.50	.8334
" "	17.09	1525	142.3	131.52	4985.93	.8172
Part Gate.	17.14	1475	147.3	131.76	4941.67	.8237
" "	17.23	1350	152	124.36	4739.63	.8063
" "	17.55	1150	133 3	92 90	3920.79	.7131
" "	17.56	1100	136 5	91 00	3892.00	.7050
" "	17 59	1050	141	89.72	3855.07	.7006
" "	17.58	1000	145	87.87	3777.48	.6989
" "	17.66	900	149.5	81.54	3619.75	.6754
" "	18.00	575	144.2	50.25	2726.05	.5421
" "	18.07	500	149.3	45.24	2616.35	.5066

Walsh Double Turbine.

Sent by B. E. Sanford, Sheboygan Falls, Wisconsin.



48-inch wheel.

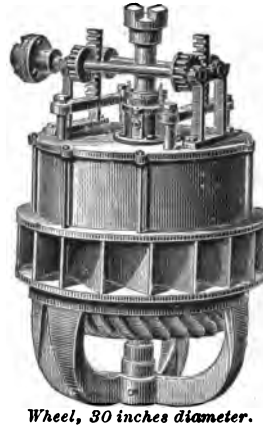
The two wheels represented above were placed together forming one with divided discharge, as represented in the small wheel at the right. The curb had cylinder gate without flange.

Data below for one minute. Multiply revolutions by 20. Sept. 8, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.29	2525	000	000		000
" "	17.44	1250	129	97.72	4110.90	.7216
" "	17.42	1350	123.5	101.04	4157.13	.7386
" "	17.38	1500	114	103.63	4224.63	.7473
" "	17.37	1600	106.3	103.07	4228.88	.7429
" "	17.38	1650	101	101.00	4228.88	.7292
" "	17.39	1550	109.5	102.86	4219.42	.7423
" "	17.39	1575	107	102.13	4224.63	.7359
" "	17.38	1525	111	102.59	4224.63	.7397
" "	17.38	1475	114.5	102.35	4211.96	.7402
Part Gate.	17.45	1350	106	86.72	4027.25	.6534
" "	17.45	1300	110.5	87.06	4023.08	.6565
" "	17.45	1275	113	87.31	4019.00	.6591
" "	17.45	1260	114.5	87.73	4019.00	.6623
" "	17.61	1000	114	69 09	3632.61	.5718
" "	17.81	750	113.6	51.63	3038.93	.5051
" "	17.60	900	122	66.54	3600.82	.5558
" "	17.60	950	120	69.09	3608.89	.5759
" "	17.73	850	112.5	57.95	3279.00	.5278
" "	17.98	675	110.6	45.24	2550.32	.5223
" "	17.98	625	115.5	43.75	2550.32	.5170
" "	18.03	450	120	32.72	2311.00	.4143
" "	18.03	500	113.5	34.39	2311.00	.4356
" "	18.24	250	114.5	17.34	1827.74	.2755
" "	18.23	350	125	26.51	2136.79	.3603
" "	18.23	400	116	28.15	2140.23	.3820

King's Turbine.

Sent by A. S. King, Pontiac, Michigan.



Wheel, 30 inches diameter.

This turbine was a central discharge, constructed with a thick crown plate that could be raised or lowered on the buckets, so that the wheel itself could be changed in depth from ten inch openings to zero—so constructed with the expectation of getting the highest percentage for the water used, whether the wheel was opened two or ten inches. There was no separate gate, the crown plate shutting down to the bottom rim of wheel, thus forming gate in itself.

Data below for one minute. Multiply revolutions by 15. Sept. 20, 1879.

Gate Opened.	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.93	920	000	00.00	1866.47	.0000
" "	17.86	450	185	37.84	1969.34	.5695
" "	17.85	500	175	39.77	1987.04	.5937
" "	17 85	550	165	41.25	1999.02	.6120
" "	17.85	600	154	42.00	2037.82	.6256
" "	17.80	650	141.6	41.83	2061.80	.6084
" "	17.80	700	130.5	41.55	2031.88	.5908
" "	17.82	575	157	41.03	2025.86	.6018
" "	17.82	590	154	41.30	2043.80	.6004
" "	17.82	610	150.5	41.73	2043.80	.6067
" "	17.81	625	146.2	41.53	2055.80	.6006
Part Gate.	17.88	550	152.5	38.12	1936.83	.5829
" "	17.87	525	158.6	37.81	1922.12	.5829
" "	17 93	450	163.8	33.50	1782.48	.5550
" "	17.93	480	156	34.03	1796.88	.5592
" "	17.93	500	152	34.54	1802.64	.5658
" "	18 01	450	150.2	29.01	1640.36	.5199
" "	18.02	425	158.5	30.62	1629.14	.5523
" "	18.10	350	164.5	26.17	1455.45	.5260
" "	18.12	375	155.5	26 51	1455 45	.5322
" "	18.24	300	154	21.00	1222.65	.4998
" "	18.34	250	139.5	15.85	1048.53	.4364
" "	18.35	200	173.5	15.77	1041.16	.4370
" "	18.35	225	159.2	16 28	1043.62	.4501
" "	18.48	140	155	9.86	808.00	.3496
" "	18.57	90	150	3.74	652 00	.1635

Tyler Wheel.

60-inch wheel, sent by John Tyler, Claremont, N. H.

In furnishing wheels for an open comparative trial, Mr. Tyler took a course alike creditable to his manhood and sense of fair dealing. He knew perfectly well that recent improvements in turbines had greatly increased their capacity, without a corresponding increase in cost, and that his wheels would have to contend against such improvements.

This turbine weighed about six tons; price, $1,000. By comparing its cost, capacity of transmission, and general efficiency with the Hercules, Victor or New American, its relative value may be approximated.

It will be noticed that after partially closing the gate, the discharge was greater than with the gate opened in full—a rather curious feature, though the same may be observed in the test of the Monarch, the second test of the Success, and others.

Data below for one minute. Multiply revolutions by 20. Oct. 8, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	16.94	1950	102.5	121.13	4730.67	.7996
" "	16.94	2000	100 5	121.81	4743.84	.8027
" "	16.94	2050	98	121.75	4774.60	.7970
Part Gate.	16.88	2000	98.6	119.51	4809.82	.7775
" "	16.88	1900	106	122.06	4809.82	.7959
" "	17.13	1800	97	105.81	4251.42	.7692
" "	17.15	1750	99	105.00	4192.08	.7733
" "	17.18	1700	100.7	103.72	4162.50	.7679
" "	17.27	1500	105	95.45	3878.45	.7545
" "	17.28	1500	105	95.45	3870.19	.7557
" "	17.28	1550	102	95.81	3890.86	.7544
" "	17.64	1200	98.2	71.41	3137.24	.6832
" "	17.65	1150	100.5	70.04	3040.77	.6909
" "	17.67	1100	104	69.33	3106.27	.6687
" "	17.85	950	98.3	56.62	2619.96	.6414
" "	17.85	850	102	52.54	2510.49	.6208
Full Gate.	16.85	2000	100.3	121.57	4757.01	.8030

Thompson Wheel.

Sent by Thompson Iron Works, Union City, Pa.

40-inch wheel, diagonal in shape, like the Houston.

Data below for one minute. Multiply revolutions by 20. Oct. 11, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.66	1800	000	000	2958.73	000
" "	17.49	900	139.6	76.14	3302.55	.6982
" "	17.47	1000	128	77.57	3314.46	.7092
" "	17.48	1100	117	78.00	3334.34	.7085
" "	17.50	1200	102.5	74.54	3330.38	.6771
" "	17.50	1075	120.5	78.50	3334.34	.7122
" "	17.50	1125	115	78.40	3342.30	.7096
" "	17.48	1100	118.6	79.06	3346.28	.7155
" "	17.48	1100	119.2	79.46	3346.28	.7192
" "	17.50	1125	117.3	79.97	3342.30	.7239
Part Gate.	17.58	1100	111	74.00	3133.18	.7113
" "	17.58	1100	112	74.66	3133.18	.7176
" "	17.56	1050	119.7	76.17	3114.64	.7529
" "	17.72	950	118	67.94	2783.48	.7292
" "	17.94	800	120	58.18	2380.93	.7212
" "	18.16	600	126.5	46.00	1963.12	.6832
" "	18.15	700	114.5	48.57	2004.19	.7069
" "	18.10	675	117.5	48.06	1993.90	.7052
" "	18.23	500	118.5	35.90	1545.00	.6748
" "	18.27	475	123	35.41	1538.57	.6671

Sherwood Wheel.

20-inch wheel.

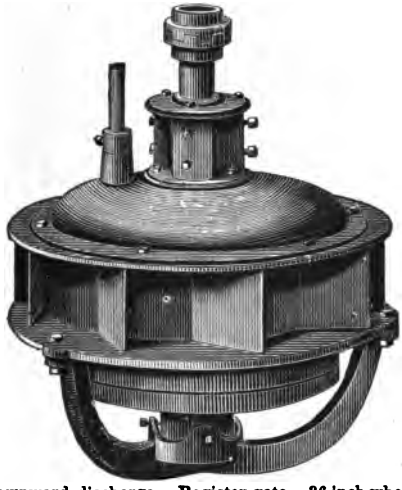
Downward discharge, similar to the Risdon, with plain cylinder gate; had been in use two years; was sent for the purpose of ascertaining the efficiency of the plan.

Data below for one minute. Multiply revolutions by 10. Oct. 7, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.31	260	248.2	19.55	835.13	.6769
" "	18.32	270	242.2	19.81	848.37	.6748
" "	18.32	280	230	19.51	848 37	.6647
" "	18.31	250	259.2	19.63	848.37	.6692
Part Gate.	18.36	260	248	19.53	805.01	.6996
" "	18.41	260	212	16.70	746.59	.6432
" "	18.43	225	255	17.38	756.00	.6606
" "	18.43	245	231.5	17.18	754.42	.6543
" "	18.43	235	243	17.30	754.42	.6588
" "	18.43	230	251	17.49	754.42	.6508

Perry's Improved Turbine.

Sent by Wm. F. Perry, Bridgton, Me.



Downward discharge. Register gate. 36-inch wheel.
Data below for one minute. Multiply revolutions by 15. Oct. 13, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.98	630	201	54.81	2108.42	.7655
" "	17.96	650	191.5	56.58	2120.50	.7866
" "	17.96	700	182	57.90	2135.60	.7992
" "	17.95	750	173	58.97	2138.64	.8133
" "	17.95	800	161.5	58.72	2144.70	.8075
" "	17.95	725	177	58.32	2129.56	.8077
" "	17.95	740	175	58.86	2132.58	.8142
" "	17.95	760	170.5	58.90	2138.64	.8124
" "	17 94	775	167.5	59.01	2147.73	.8109
Part Gate.	18.06	700	157	49.95	1894.69	.7727
" "	18.06	690	160.5	50.33	1894.69	.7786
" "	18.06	675	165	50.62	1891.77	.7844
" "	18.06	665	167.5	50.63	1888.85	.7859
" "	18.17	550	155	38.75	1592.69	.7090
" "	18.16	550	161	40.25	1628 89	.7204
" "	18.13	565	173.5	44 56	1719.00	.7569
" "	18.10	575	174.5	45.60	1761.74	.7571
" "	18.10	595	169.7	45.89	1761.74	.7620
" "	18.22	465	173.5	36.67	1513.82	.7043
" "	18 22	485	169	34.22	1532.00	.6490
" "	18.47	350	146	23.22	1144.80	.5414
" "	18.42	270	165	22.25	1072.42	.5964
" "	18.30	300	158	21.72	1099.79	.5694
" "	18.40	290	160	21.09	1079.92	.5610
" "	18.42	250	169	19.20	1069.90	.5158
" "	18.37	340	157.5	21.31	1158.96	.5318
" "	18.30	375	167	28.46	1298.89	.6339

Reynold's Champion Wheel.

24-inch wheel, sent by Bloomer & Co., Ellenville, N. Y.

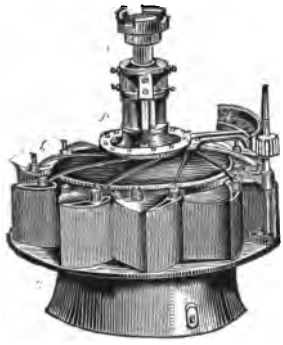
Downward discharge. Register gate.

Data below for one minute. Multiply revolutions by 10. Oct. 13, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse power	Cubic feet	Per Cent.
Whole Gate.	18.34	550	000	000	1010.64	000
" "	18.32	275	313	26.08	1047.06	.7198
" "	18.30	300	304	27.63	1059.28	.7564
" "	18.30	325	290.5	28.48	1071.55	.7689
" "	18.30	350	276.7	29.37	1081.39	.7857
" "	18.29	375	260	29.54	1091.20	.7837
" "	18.29	400	243.7	29.50	1103.63	.7649
" "	18.28	365	266 5	29.47	1088.75	.7836
" "	18.28	385	251.5	29.34	1096.20	.7753
Part Gate.	18.27	375	260	29.54	1088.75	.7862
" "	18.23	350	273	28.95	1081.39	.7755
" "	18.28	375	257.5	29.26	1091.20	.7767
" "	18.28	350	268	28.42	1083.85	.7594
" "	18.28	365	262.5	29.03	1086.30	.7742
" "	18.27	350	263	27.89	1081.39	.7492
" "	18.28	315	282.5	26.96	1071.55	.7287
" "	18.27	335	272.5	27.66	1071.55	.7479
" "	18.27	350	262	27.78	1071.55	.7512
" "	18.34	300	261	23.72	950.79	.7202
" "	18.40	275	236	19.66	848.08	.6670
" "	18.41	250	256.5	19.43	834.35	.6697
" "	18.41	245	260.5	19.34	834.35	.6666
" "	18 46	200	252.5	15.30	746.66	.5877
" "	18.46	190	260	14.99	737.83	.5827
" "	18.54	125	243	9.20	584.11	.4498
" "	18.54	110	260	8.66	573.81	.4310
" "	18.60	90	260	7.09	521.12	.3873

New American Wheel.

48-inch wheel, sent by Stout, Mills & Temple, Dayton, Ohio.



This turbine has the same curb in form as the well-known American Turbine, made by that company; but the wheel is downward discharge—very similar in form and plan to the Swain.

Data below for one minute. Multiply revolutions by 20. Oct. 14, 1879.

Gate Opened.	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	16.45	2935	000	000	5397.95	000
" "	16.33	2000	110.5	133.94	5603.83	.7749
" "	16.32	2050	108.3	134.55	5608.43	.7783
" "	16.30	2100	104 6	133.12	5594 63	.7727
" "	16.29	2150	101.5	129.48	5599.23	.7516
" "	16.32	2025	109	133.77	5590.03	.7763
" "	16.32	2075	105.5	132.67	5603.83	.7679
Part Gate.	16.40	2050	107	132.93	5484.60	.7824
" "	16.40	2025	108	132.54	5475.46	.7814
" "	16.38	2075	106.3	133.68	5484 60	.7879
" "	16.49	2000	108.5	131.51	5280.09	.7996
" "	16.43	2025	108.8	131.07	5271.00	.8013
" "	16.52	1975	109.1	130.58	5257.46	.7961
" "	16.69	1900	109	125.51	4984.41	.7989
" "	16.88	1800	106	115.63	4546.23	.7978
" "	16.90	1700	111.7	115.05	4477.28	.8051
" "	16.89	1750	108.3	114.86	4511.71	.7962
" "	16.87	1775	107.3	115.73	4529.00	.8019
" "	17.16	1500	108.8	98.91	3966.32	.7694
" "	17.15	1525	108.2	100.00	3962.18	.7792
" "	17.17	1475	110 3	98.54	3937.34	.7717
" "	17.43	1175	111.3	79.25	3336.22	.7216
" "	17.44	1200	109.4	79 56	3348.02	.7214
" "	17.60	1050	106.3	67.64	2969.24	.6853
" "	17.67	1000	103.3	62.60	2829.91	.6627
" "	17.68	975	106	62.63	2818.70	.6638
" "	17.69	950	108.3	62.35	2774.00	.6728
Whole Gate.	16.31	2050	106.3	132.07	5567.06	.7701

Humming Bird Wheels.

48-inch wheels, sent by Willis Read, Danbury, Conn.

Through some peculiarity of construction, which, without illustration, is indescribable, these wheels keep up a constant humming sound while running; hence their name. Mr. Read was promptly on hand with his wheel, which was tested Sept. 6. From information obtained by the test, he took a new departure and constructed another wheel, which was tested Oct. 15. The results of each may be found below. The workmanship of the wheels would hardly cause manufacturers to look for machinery in Danbury.

Data below for one minute. Multiply revolutions by 20.

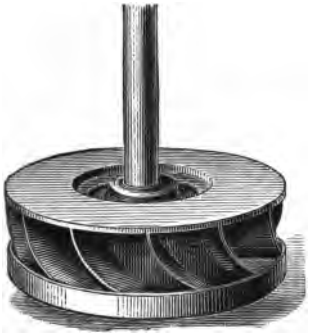
Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.95	1550	000	000		000
" "	18.02	750	103	46.81	2187.30	.6287
" "	18.02	775	1·2	47.91	2211.71	.6366
" "	18.00	800	100.5	48.72	2218 70	.6473
" "	18.00	825	98.2	49.60	2232.70	.6533
" "	17.98	850	97.5	50.22	2246.73	.6581
" "	17.98	875	96	50.90	2260.77	.6629
" "	17.97	900	95	51.81	2271.33	.6720
" "	17.95	925	93.5	52.42	2306.62	.6702
" "	17.94	950	90	51.82	2338.53	.6537
Part Gate.	18.40	425	98.3	24.03	1210.67	.5734
" "	18.41	400	100	24.24	1196.08	.5828
" "	18.45	400	92	22.30	1089.69	.5872
" "	18.41	420	96.7	24.78	1255.49	.5670
" "	18.40	500	91.5	27.72	1269.56	.6283
" "	18.34	600	88.5	32.18	1398.88	.6640
" "	18.32	600	91	33.09	1472.63	.6493
" "	18.18	700	96	40.72	1827.76	.6483
" "	18.16	750	93.2	42.36	1887.49	.6541
" "	18.13	775	93.5	43.94	1944.34	.6598
" "	18.22	650	95	37.42	1732.81	.6275

Tested October 15.

Whole Gate.	17.81	1600	000	000	2642.89	000
" "	17.85	800	107.5	52.12	2474.90	.6246
" "	17.85	850	103	53.06	2485.76	.6331
" "	17.84	900	95.8	52.25	2551.18	.6078
" "	17.83	825	106	53.00	2503.88	.6286
" "	17.83	850	103.3	53.21	2514.77	.6283
" "	17.85	875	99.6	52.78	2554.83	.6127
Part Gate.	18.06	700	97.3	41.27	2042.38	.5923
" "	18.02	675	100 3	41.03	2035.56	.5922
" "	18.04	650	102.6	40.41	2035.56	.5826
" "	18.20	500	104.2	31.57	1683.73	.5454
" "	18.18	525	103.2	32.83	1680.51	.5689
" "	18 32	400	95.6	23.17	1328.28	.5041
" "	18.34	350	103	21.90	1301.28	.4947
" "	18.57	200	93.5	11.94	908.29	.3760
" "	18.44	250	105	11.59	1079.87	.3081
" "	18.06	650	106	41.75	1981.13	.6192
" "	18.20	500	106.8	32.36	1651.78	.5699
" "	18.35	350	106	22.48	1277.42	.5078
Whole Gate.	17.84	850	107.5	55.38	2532.96	.6489

Success Wheel.

36-inch wheel, sent by S. M. Smith, York, Pa.



Called the Improved Success, very fragile in construction.

Data below for one minute. Multiply revolutions by 15. Oct. 16, 1879.

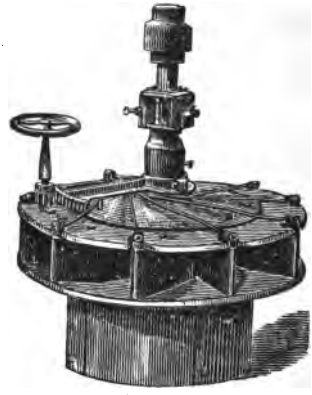
Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.99	1350	000	000	2243.17	0000
" "	17.93	675	191.5	58.75	2380.46	.7287
" "	17.90	750	185	62.76	2433.92	.7627
" "	17.83	800	178.2	64.80	2437.50	.7867
" "	17.87	850	170.5	65 88	2484.14	.7857
" "	17.87	900	162.5	66.47	2494.94	.7893
" "	17.86	950	153.3	66.19	2523.82	.7774
" "	17.85	1000	145.5	66.13	2523.82	.7773
" "	17.86	875	165	65.62	2491.34	.7809
" "	17.85	900	161.5	66.06	2502.15	.7829
" "	17.85	925	157	66.07	2512.98	.7798
Part Gate.	17.96	800	163.2	59.34	2197.96	.7959
" "	17.98	825	159.2	59 70	2208.37	.7961
" "	18.19	550	163.5	40 87	1649.44	.7212
" "	18.19	575	159.2	41.60	1653.80	.7321
" "	18.09	650	165	48.75	1876.29	.7604
" "	18.26	450	171.5	35.07	1477.05	.6884
" "	18.26	475	165	35 62	1486.77	.6947
" "	18.25	500	160	36.36	1499.10	.7037
" "	18.25	525	154.5	36.86	1511.46	.7076
" "	18.37	375	159.5	27.18	1223.47	.6403
" "	18.37	375	157.5	26.84	1217.67	.6352
" "	18.34	375	162.5	27.69	1258.46	.6351

Second test of the same wheel, the buckets having been chipped and other changes made.

Whole Gate.	17.78	900	164.1	67.13	2482.66	.8051
Part Gate.	17.80	800	179	65.09	2410.98	.8031
" "	17.80	800	178	64.72	2378.93	.8091
" "	17.88	800	166	60.36	2168.65	.8241
" "	17.76	875	167.5	66.61	2464.68	.8051
" "	17.74	925	161.2	67.61	2482.66	.8126
" "	17.75	900	165	67.50	2493.46	.8076

Tait Wheel.

Sent by Thomas Tait, Rochester, N. Y.

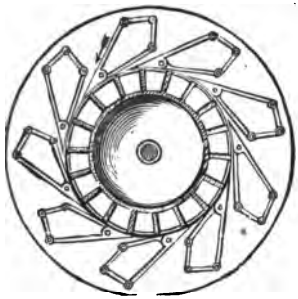


36-inch wheel.

This wheel discharged downward. It had thick cast iron buckets, left square at the edge, between the hoop and crown plate.

Data below for one minute. Multiply revolutions by 15. Oct. 17, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.25	1125	000	0'0	1685.09	000
" "	18.27	550	156.5	39.12	1614.60	.7022
" "	18.26	560	154	39.20	1618 97	.7021
" "	18.25	570	152.5	39.51	1622.16	.7066
" "	18.25	580	151.5	39.94	1627.35	.7119
" "	18 25	590	150	40.22	1633.73	.7142
" "	18.25	600	147.5	40.22	1640.13	.7109
" "	18.25	610	146.2	40.50	1643.33	.7149
" "	18.21	620	144.7	40.77	1643.33	.7202
" "	18.24	630	142.5	40.81	1656.15	.7153
" "	18.24	650	139	41.06	1665.78	.7154
" "	18.22	700	133	42.31	1694.78	.7271
" "	18.21	750	125	42.61	1720.68	.7200
" "	18.20	800	113	41.09	1749.96	.683
Part Gate.	18.30	500	158.3	35.97	1485.61	.7005
" "	18.30	515	156	36.82	1494.94	.7126
" "	18.29	530	152.5	36.73	1507.41	.7053
" "	18.29	545	149.7	37.11	1516.78	.6921
" "	18.33	500	152	34.54	1420.78	.7022
" "	18.32	515	149.2	34.92	1426.92	.7074
" "	18.37	450	153.5	31.40	1293.67	.6996
" "	18.37	480	147.5	32.18	1311.62	.7071
" "	18.42	430	146	28.53	1196.28	.6854
" "	18.43	400	152.5	27.72	1173.01	.6788
" "	18.49	350	145	23.06	1011 04	.6530
" "	18.50	320	155	22.54	994.39	.6487
" "	18.56	250	157	17.84	848.19	.6000
" "	18.56	270	147.5	18.10	848.19	.6080



TAIT *(Continued)*.

Another wheel, similar to the first, but the edge of the buckets had been finished "quarter round." It was tested in the same curb as the first.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.18	550	158.3	39.57	1779.38	.6476
" "	18.17	575	155	40.51	1782.66	.6620
" "	18.17	600	150	40.90	1818.84	.6553
" "	18.16	625	148	42.04	1838.66	.6667
" "	18.16	650	144	42.54	1845.26	.6722
" "	18.15	675	140.5	43.11	1871.83	.6718
" "	18.14	700	136	43.27	1888.48	.6687
" "	18 13	725	133.5	43.99	1905.18	.6743
" "	18 13	750	129.5	44.14	1911.87	.6742
" "	18.13	775	125	44.03	1918.57	.6701
" "	18.11	800	121.5	44 18	1938.71	.6663
Part Gate.	18.18	600	146.2	39.87	1802.36	.6592
" "	18.19	575	150	39.20	1749.96	.6520
" "	18.25	470	160.5	34.28	1601.88	.6208
" "	18.24	500	155	35.22	1615.78	.6327
" "	18.23	530	150.2	36 18	1637.00	.6419
" "	18.28	470	151.5	32 36	1504 29	.6231
" "	18.35	410	151.7	28.27	1341.69	.6079
" "	18.43	350	149.8	23.83	1170.11	.5850
" "	18.50	295	150.2	18.09	972.31	.5324
" "	18.55	240	143.5	15 65	850.80	.5250
" "	18.52	270	145	17 79	934.03	.5445
" "	18.53	250	150	17.04	924.88	.5264

Second test of the No. 1 Tait wheel, the buckets having been "chipped" back three-eighths of an inch, and edges rounded on front side, so as to leave them sharp on back side, between the hoop and crown plate.

Whole Gate.	18 29	700	144.5	45.98	1710.11	.7787
" "	18.27	725	140	46.13	1719.83	.7772
" "	18 32	675	148.7	45.63	1697.18	.7771
" "	18.31	650	151.5	44.76	1687.50	.7670
Part Gate.	18.34	650	144.7	42.75	1610.69	.7663
" "	18.36	600	153.5	41.86	1579 00	.7645
" "	18 39	600	145.5	39.68	1509.92	.7566
" "	18.40	580	149	39.28	1500.57	.7533
" "	18 45	525	150	35.79	1380.58	.7440
" "	18.50	475	149.2	31.56	1248.86	.7230
" "	18.50	450	152	31.09	1240.00	.7176
" "	18.57	350	157.2	25.01	1161.43	.6717
" "	18.57	375	150.5	25.65	1067.07	.6853
" "	18.66	300	141 5	19.29	869.71	.6293
" "	18.67	270	151.2	18.55	843.22	.6238
Full Gate.	18.23	750	135	46.02	1742.56	.7648

Nonesuch Wheel.

40-inch wheel, sent by A. S. Clark, Turners Falls, Mass.

The designer sends the following description:

The wheel consists of downward discharge buckets, enclosed by bell-shaped cylinders. The one forming the hub of the wheel has the concave surface next to the buckets. The other forms the flange or band which encloses the lower or reacting parts of the buckets, and has the convex surface next to them, or larger end downward. By this construction, the lower parts of the buckets are expanded on their outer extremity, which gives a very easy discharge. The curb of the wheel has a short draft tube in which is the step on which the wheel revolves. The water enters the wheel at the side and above the outer flange, through a system of straight chutes, within which is a cylinder gate having on the lower edge fins or blades, which extend into the chutes. The downward pressure on these blades and the weight of the gate is counterbalanced by an upward pressure on an external sectional flange near the top of the gate, and within the dome in which the gate rises to open. By this means the gate opens easy under pressure. The wheel is constructed on the theory that water should not be changed in direction horizontally after leaving the chutes, but take a downward direction only, as the wheel absorbs the power of the moving water.

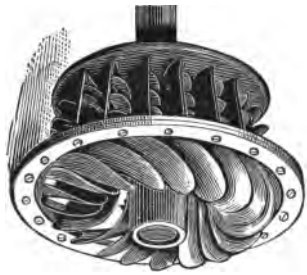
This wheel was very deep, like the Hercules; conical in shape, 40 inches in diameter at the top and 48 at the bottom, which turned outward like the Risdon—hardly distinguishable in outward appearance of curb from the Hercules.

Data below for one minute. Multiply revolutions by 20. Oct. 21, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.37	2100	000	000	3999.93	000
" "	17.14	1100	157.6	105.06	4449.00	.7294
" "	17.15	1200	149	108.36	4453.29	.7512
" "	17.12	1300	139.2	109.67	4461.89	.7600
" "	17.15	1400	131	111.15	4470.51	.7676
" "	17.13	1500	118.5	107.74	4470.51	.7448
" "	17.12	1600	105.5	102.30	4449.00	.7112
" "	17.11	1375	130.5	108.75	4444.38	.7571
Part Gate.	17.12	1425	125.5	108.75	4444.38	.7503
" "	17.12	1400	128.2	108.77	4449.00	.7562
" "	17.19	1400	120	101.82	4256.59	.7368
" "	17.19	1350	125.5	102.63	4239.56	.7461
" "	17.42	1300	106	83.51	3711.41	.6839
" "	17.38	1300	114	89.81	3859 00	.7060
" "	17.38	1200	124.7	90.70	3838.38	.7206
" "	17.48	1100	125	83.33	3865.58	.7079
" "	17.65	950	125	71.96	3197.18	.6750
" "	17.75	800	130	63.03	2935.63	.6404
" "	17 75	850	123.5	63 62	2928 04	.6481
" "	17.84	700	127.5	54.09	2666.18	.6021
" "	17.92	675	123	50.31	2512.67	.6053
" "	17 92	650	126.5	49.83	2501.81	.5885
" "	18.04	500	131	39.69	2224.52	.5237
" "	18.03	550	122.5	40.83	2221.03	.5398
" "	17.09	1400	126	106.91	2449.00	.7443

Hercules Wheel.

Holyoke Machine Co., Holyoke, Mass.



33-inch wheel; weight, 4,000 pounds; price, $550.
Tested Nov. 4.

Data below for one minute. Multiply revolutions by 20.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	16.87	2500	000	000	5137.95	.000
" "	17.12	1000	184.5	111.81	4608.44	.7503
" "	17.09	1100	177.2	118.13	4664.96	.7844
" "	17.06	1200	166.4	121.02	4691.06	.8004
" "	17.07	1300	154.6	121.80	4721.69	.8000
" "	17.04	1400	142.6	121.00	4743.56	.7926
" "	17.02	1500	130	118.18	4765.41	.7716
" "	17.05	1250	160.5	121.59	4708.58	.8017
" "	17.04	1350	148.5	121.50	4721.69	.7995
" "	17.04	1275	157	121.32	4704.15	.8013
" "	17.04	1300	154.5	121.72	4708.58	.8031
" "	17.04	1325	150.2	120.61	4712.95	.7951
Part Gate.	17.13	1300	148	116.60	4513.21	.7984
" "	17.14	1250	154.5	117.04	4560.34	.8033
" "	17.25	1200	153.5	111.63	4206.06	.8147
" "	17.23	1175	156	111.09	4197.56	.8133
" "	17.28	1100	158.5	105.66	4038.24	.8016
" "	17.26	1150	155	108.63	4059.11	.8209
" "	17.25	1100	155	103.33	3926.08	.8079
" "	17.42	1050	156	99.27	3696.75	.8162
" "	17.40	1050	150	95.45	3527.48	.8214
" "	17.38	1000	153.5	93.03	3507.49	.8079
" "	17.39	1000	145	87.87	3368.55	.7924
" "	17.21	900	155	84.55	3270 35	.7953
" "	17.33	850	151.6	78.09	3095.86	.7705
" "	17 35	800	150	72.72	2905.45	.7628
" "	17.35	750	152.5	69.31	2860.30	.7896
" "	17.37	730	155	68.57	2841.55	.7855
" "	17.51	650	157	61.84	2676.87	.7168
" "	17.50	675	153	62.59	2656.17	.7129
" "	17.34	600	150	54.54	2428 14	.6859
" "	17.40	580	152.5	53 65	2381.87	.6848
" "	17.40	550	155.5	51 84	2360.60	.6683

Hercules Wheel.

Holyoke Machine Co., Holyoke, Mass.

33-inch wheel; weight, 4,000 pounds; price, $550.

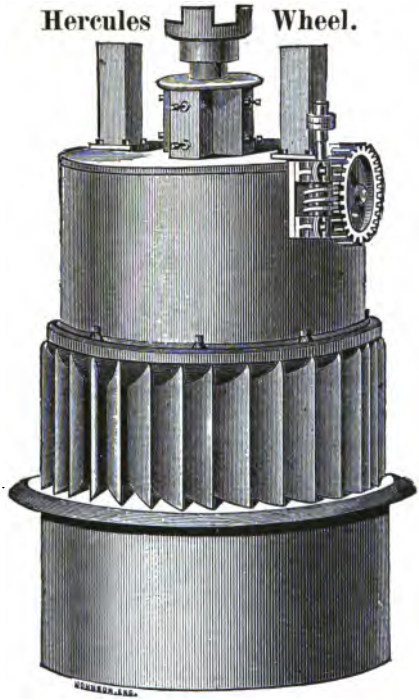
Tested Nov. 11.

Same wheel as tested Nov. 4th. It stood in the flume during the interval, and received some hard knocks during the time from a gang of mill-wrights who were fitting up the nearly horizontal draft tube illustrated further along in report. Previous to this second trial the step was taken out, examined and quite likely "trued up," after which operation the wheel became unsteady in motion and difficult to control by brake, though quite the reverse during the first test.

Data below for one minute. Multiply revolutions by 20.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	16.63	1275	152	117.42	4661.56	.7995
" "	16.68	1300	148.7	117.15	4652.86	.7991
" "	16.67	1250	154.5	117.04	4652.86	.7989
" "	16.65	1250	151.6	114.85	4639.84	.7879
" "	16.70	1200	159.2	115.78	4631.16	.7926
Part Gate.	17.00	1150	154	107.33	4178.34	.8000
" "	17.00	1175	148	105.39	4174.14	.7510
" "	17.08	1100	156	104.00	3990.56	.8060
" "	17.09	1125	154	105.00	4015.36	.8101
" "	17.28	1025	154.5	95.98	3675.20	.8001
" "	17.28	1050	153	97.36	3679.24	.8110
" "	17.37	1025	147	91.31	3514.60	.7919
" "	17.40	1000	150.2	91.03	3486.74	.7944
" "	17.54	900	155	84.54	3297.41	.7738
" "	17.67	950	151	86.93	3375.90	.7756
" "	17.74	850	156	80.36	3099.87	.7755
" "	17.23	1300	156.7	123.46	4766.24	.7961
" "	17.23	1350	151	123.54	4740.01	.8009
" "	17.68	1050	156.7	99.72	3707.58	.8054
" "	17.68	1100	150	100.00	3736.00	.8015
" "	17.99	800	150	72.72	3015.83	.7100
" "	18.10	650	155	61.06	2566.63	.6955
" "	18.08	675	151.5	61.97	2592.00	.7000
" "	18.10	600	155.5	56.54	2469.49	.7012
" "	18.10	640	151	58.56	2483.81	.6897
" "	18.08	650	150.2	59.70	2473 07	.7070
" "	18.09	675	147.5	60.49	2505.33	.7063

Hercules Wheel.

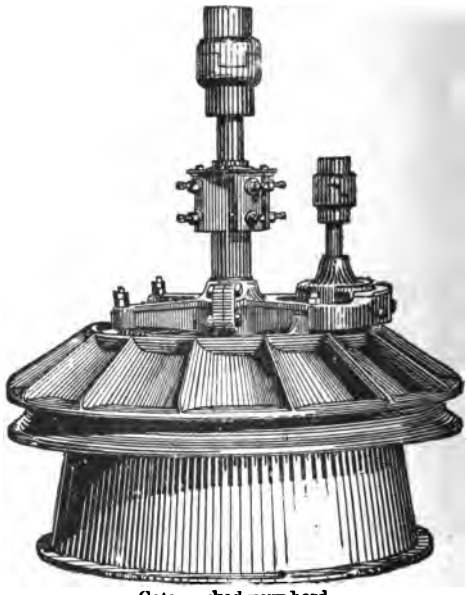


A third test, Nov. 12, step having again been taken out and examined. Data below for one minute. Multiply revolutions by 20.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.28	1300	155.3	122.35	4732.11	.7923
" "	17.27	1325	152.5	122.46	4710.31	.7984
" "	17.26	1350	150.5	123.13	4723.04	.7996
" "	17.26	1375	146.5	122.08	4745.22	.7892
Part Gate.	17.35	1300	150	118.18	4510.79	.7996
" "	17.36	1250	157	118.94	4493.89	.8071
" "	17.42	1250	147.7	111.89	4238.33	.8024
" "	17.43	1200	154.5	112.37	4217.74	.8091
" "	17.43	1225	152	112.85	4217.74	.8128
" "	17.55	1150	149.6	104.26	3913.03	.8038
" "	17.55	1125	152.5	103.97	3899.56	.8044
" "	17.57	1050	153.5	97.63	3700.64	.7964
" "	17.58	1050	146	92.90	3539.76	.7904
" "	17.59	1000	151	91.51	3527.79	.7809
" "	17.62	975	154	91.00	3499.89	.7812
" "	17.28	950	145	83.48	3322.19	.7700
" "	17.30	900	150.5	82.09	3276.29	.7671
" "	17.25	850	148	76.24	3070.62	.7620
" "	17.25	825	151.2	75.60	3062.99	.7676
" "	17.01	750	147.7	67.13	2832.72	.7377
" "	16.99	725	151	66.34	2814.09	.7346
" "	17.20	650	153	60.27	2604.47	.7123
" "	17.32	600	153.5	55.81	2478.28	.688
" "	17.37	600	150.5	54.72	2442 58	.6

Houston Wheel.

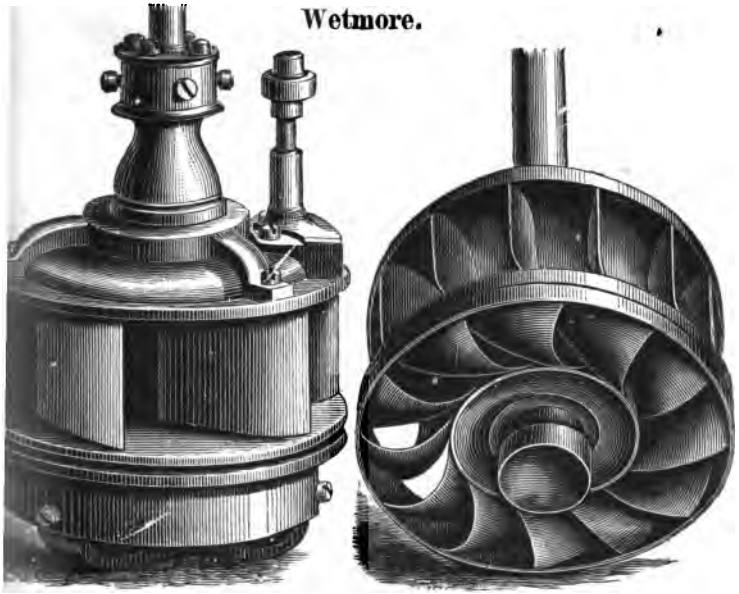
40-inch wheel, sent by Fales & Jenks Machine Co., Pawtucket, R. I.



Gate worked very hard.

Data below for one minute. Multiply revolutions by 15. Nov. 14, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	16.41	2125	000	000	2786.04	000
" "	16.56	1050	143.6	68.53	2697.24	.8123
" "	16.57	1075	140	68.41	2704.60	.8083
" "	16.56	1100	137	68.50	2697.24	.8120
" "	16.56	1125	133.5	68.27	2704.60	.8069
" "	16.54	1025	146.7	68.55	2682.52	.8179
Part Gate.	16.62	700	138.5	44 06	2145.70	.6541
" "	16.57	650	149.5	44.17	2176.65	.6484
" "	16.53	675	147.5	45.25	2200.82	.6585
" "	16.53	635	146	46.12	2200.82	.6712
" "	16.59	900	147.5	60.34	2522.32	.7634
" "	16.59	925	144.5	60.75	2522.32	.7688
" "	16.88	800	143	52.00	2315.85	.7043
" "	16.70	730	141	50.63	2298.30	.6984
" "	16 68	770	145	50.75	2284.30	.7053
" "	16.60	600	142	38.72	2510.22	.5743
" "	16.54	575	144.5	37.76	2033.38	.5943
" "	16.94	450	142	28.01	1820.95	.4464
" "	16 87	425	145.5	23.10	1807.91	.4876
" "	17.00	350	133 5	21.23	1448.80	.4564
" "	17.25	150	145	9.88	1346.51	.2252



To the Engineers making Hydro-Dynamic Experiments for Water Power Co., Holyoke, Mass.

GENTLEMEN: The wheel which we had tested by you was an experimental one, differing somewhat from the others heretofore tested, and from what we furnish our customers. The results you obtained did not warrant us in continuing its manufacture, so it has been abandoned, and we have returned to our original plans represented above.

Respectfully,

SULLIVAN MACHINE CO.

Nov. 14, 1879. C. B. RICE, *Treas.*

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.38	350	250	39.77	1508.19	.7596
" "	18.38	375	237	40.36	1511.29	.7692
" "	18.38	400	224	40.72	1511.29	.7762
" "	18.38	425	210.5	40.66	1505.09	.7781
" "	18.38	450	196	40.09	1502.00	.7689
" "	18.39	390	227.5	40.32	1502.00	.7727
" "	18.38	410	217	40.44	1498.89	.7772
Part Gate.	18.44	350	223.5	35.51	1361.62	.7488
" "	18.20	300	199	27.13	1144.66	.6894
" "	18.21	275	216	27.00	1138.96	.6862
" "	18.21	260	223.5	26.41	1138 96	.6741
" "	18.39	200	204	18.54	917.75	.5818
" "	18.39	175	225	17.89	917.75	.5613
" "	18.53	125	222	12.61	761.30	.4733
" "	18.70	275	225	28.12	1176 21	.6769

Houston Wheel.

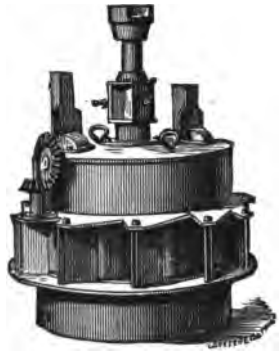
36-inch wheel, sent by one who had purchased the wheel.

Data below for one minute. Multiply revolutions by 15. Nov. 28, 1879.

Gate Opened.	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	14.07	550	165.8	41.45	1944.61	.8022
" "	14.05	600	155	42.27	1944.61	.8192
" "	14.04	625	149.2	42.38	1946.63	.8166
" "	14.05	650	143	42.25	1956.67	.8129
" "	14.01	675	138	42.30	1964.81	.8135
Part Gate.	14.11	625	146.2	41.53	1918.46	.8121
" "	13.62	600	135.5	36.95	1812.81	.7925
" "	13.66	575	142	37.11	1818.75	.7907
" "	14.15	500	136.5	31.02	1635.19	.7099
" "	14.29	450	149.2	30.51	1623.66	.6960
" "	13.85	250	136	15.45	1223.47	.4827
" "	13.68	225	146.5	14.98	1202.14	.3869
" "	14.58	120	139	7.58	922.81	.2983
" "	14.45	120	142	7.74	939.37	.3019
" "	14 28	120	148.5	8.10	964.36	.3114
Test with blocks in four of the chutes.						
	14.28	450	141.5	30.31	1503.84	.7473
	14.27	425	146.5	28.30	1488.81	.7053
Test with blocks in seven of the chutes.						
	14.56	300	135	18 40	1100 52	.6079
	14.28	275	137.7	17.22	1057.45	.6037
	14.46	250	146	16.59	1054.03	.5763

Royer Wheel.

24-inch wheel, sent by R. R. Royer, Ephrata, Pa.



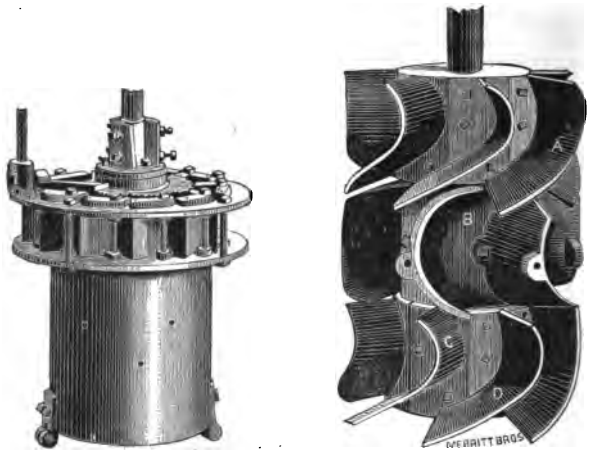
Downward discharge, having plain cylinder gate.

Data below for one minute. Multiply revolutions by 10. Dec. 5, 1879.

Gate opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	18.05	225	277.5	18.92	829.98	.6686
" "	18.02	250	261	19.77	840.29	.6913
" "	18.00	275	249.5	20.80	854.88	.7158
" "	17.98	300	238	21.63	867.91	.7339
" "	17.97	325	227.5	22.41	877.72	.7184
" "	17.95	350	213.7	22.66	889.19	.7517
" "	17.93	375	198.5	22.49	897.41	.7400
" "	17.93	400	181.2	21.96	905.66	.7161
" "	17.95	340	220.5	22.71	885.91	.7562
" "	17.95	360	206.5	22.52	890.83	.7456
Gate closed 4 turns. . .	17.96	325	228	22.45	885.91	.7471
" " 4 " . .	17.96	340	207.5	21.37	885.91	.7595
" " 8 " . .	17.95	325	216.7	21.34	897.41	.7014
" " 8 " . .	17.96	315	223	21.28	895.96	.7003
" " 12 " . .	17.96	300	215	19.54	884.27	.6514
" " 12 " . .	17.97	290	222	19.50	879.35	.6519
" " 16 " . .	18.03	250	211	15.98	812.90	.5772
" " 16 " . .	18.02	235	223	15.88	798.48	.5843
" " 20 " . .	18.15	175	214	11.35	683.14	.4847
" " 20 " . .	18.15	165	222.5	11.25	679.54	.4828
" " 24 " . .	18.30	75	226	5.14	529.35	.2745

Monarch Wheel.

Sent by Albred & Koellsch, Randleman Mf'g Co., High Point, N. C.



Three wheels, placed one above the other, the middle wheel being loose on shaft, but being bolted firmly to the curb—arranged in this manner that it might act as chutes to the lower wheel. Chutes and gates to upper wheel similar to the Leffel, but so very leaky as to be anything but creditable to the workmanship.

HIGH POINT, N. C., August 15, 1879.

W. A. CHASE, ESQ.,

Dear Sir: I have a turbine water wheel, finished; size, sixteen inches—a new invention, which has not been tested except by myself. It will use the *water twice*, and *increases the power one-quarter over any wheel known*. My 16-inch wheel run over *eight horse* power, under *nine* foot *head*, with *34 square inches* discharge. As the test is open to all wheels, I would be pleased to send on my wheel to *you*, under such *rule* and *regulations as you desire*, for a test with other wheels.

Very respectfully,

H. L. KOELLSCH.

The letter of Mr. Koellsch is given as the best means of introducing his device and ideas; also, as a sample of hundreds of other letters received of the same tenor.

During the past few years many patents have been issued for devices known to be perfectly worthless by those acquainted with the subjects to which they belong. Particularly has this been the case in turbine plans. It is hardly possible to conceive of a device, no matter how absurd, that has not been tried in the

hopes of circumventing nature in its claim for friction and waste, or, what is more generally the case, hoping to achieve "perpetual motion" through a double use of the same fall of water. Boyden's "Diffuser," or the "Double Turbines" of Wynkoop, Leffel, or any other make, have proved equally fallacious. The highest results have been obtained from the single, simple plans. As the most effective means of presenting this fact to Mr. Koellsch, the Monarch was first tested in the combined form designed. The results may be seen in the first table below. Then the lower wheel C and chutes B were removed and the wheel A alone tested; results obtained in the lowest table. Whenever the efficiency of a single turbine is increased by the addition of a second wheel or diffuser beneath, it may safely be concluded that the upper wheel is defective.

Data below for one minute. Multiply revolutions by 10. Nov. 15, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.48	75	265.5	6.09	420.92	.4145
" "	18.49	85	250	6.40	423.66	.4326
" "	18.49	95	288.3	6.86	427.76	.4592
" "	18.51	105	223	7.06	429.14	.4703
" "	18.51	120	207.5	7.54	429.14	.5025
" "	18.51	130	172	7.56	429.14	.5007
" "	18.51	140	182	7.72	430.50	.5135
" "	18.51	150	166	7.54	433.24	.4978
Gate closed 5 turns. . .	18.51	130	194.5	7.66	430.50	.5095
" " 10 " . .	18.51	135	187	7.65	430.50	.5087
" " " " . .	18.52	135	187	7.65	429.14	.5090
" " 15 " . .	18.53	135	193.7	7.92	418.19	.5411
" " " " . .	18.52	140	187	7.90	415.47	.5426
" " " " . .	18.55	130	194.5	7.66	383.11	.5703
" " " " . .	18.56	140	179.5	7.61	376.44	.5767
" " " " . .	18.67	75	152.6	3.46	242.80	.4135
" " " " . .	18.65	95	184	5.29	232.24	.5139

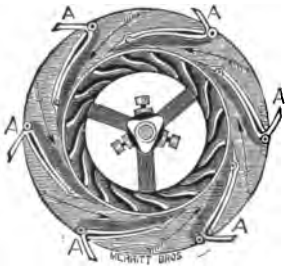
After the above tests were made, the lower wheel and set of chutes were removed.

Test of upper wheel A.

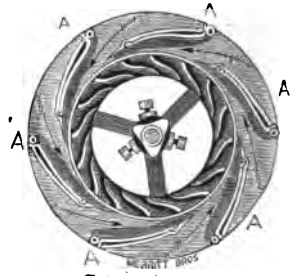
Whole Gate.	18.32	150	267	9.00	602.24	.4319
" "	18.33	140	239	9.71	594.81	.4405
" "	18.34	150	184.5	8.33	587.40	.4119
Gate closed 5 turns. . .	18.34	130	270.3	10.64	605.22	.4847
" " " " . .	18.35	140	232.5	9.86	600.75	.4775
" " 10 " . .	18.35	130	277.5	10.93	605.22	.5210
" " " " . .	18.37	140	232.5	9.86	590.36	.4813
" " 15 " . .	18.37	130	293.5	11.56	578.54	.5759
" " " " . .	18.38	140	247.5	10.50	565.33	.5350
" " 13 " . .	18.39	130	290.5	11.44	539.11	.5969
" " " " . .	18.37	140	239	10.17	524.63	.5587
" " 21 " . .	13.46	110	267	5.90	429.14	.5942
" " " " . .	18.47	105	235	7.47	404.62	.5292
" " 22½ " . .	18.65	75	263.3	5.98	317.65	.5344
" " 24 " . .	18.62	50	215	3.25	212.80	.3806

New American Wheel.

48-inch wheel, sent by Stout, Mills & Temple, Dayton, Ohio.



Chutes and gates complete.



Gates cut away.

Another turbine of the same size, but of increased discharge, made after the test of the one recorded upon the opposite page. The capacity of this wheel is double that of the old 48-inch American with central discharge.

Data below for one minute. Multiply revolutions by 20. Jan. 3, 1880.

	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	13.36	1650	109	109.00	5823.77	.7418
" "	13.22	1800	104.6	114.10	5922.79	.7715
" "	13.09	1900	96.5	111.12	6016.59	.7471
" "	12.92	2000	90.5	109.69	6030.76	.7454
" "	13.20	1750	105	111.36	5857.38	.7626
" "	13.21	1775	105	112.95	5862.04	.7723
" "	13.10	1825	100	110.60	5876.05	.7608
" "	13.06	1850	99	111.03	5885.39	.7647
" "	13.11	1800	101	110.18	5871.38	.7578
Part Gate.	13.47	1700	101.5	104.57	5685.60	.7231
" "	13.48	1750	106.5	112.95	5722.61	.7752
" "	13.70	1700	108.5	111.78	5574.99	.7749
" "	12.45	1750	96.5	102.34	5414.85	.7855
" "	12.62	1700	97	99.93	5278.71	.7943
" "	13.22	1500	112.3	102.03	5031.86	.8126
" "	13.20	1550	107.5	100.98	5054.15	.8014
" "	12.95	1700	100	103 03	5211.04	.8083
" "	13.10	1350	106	86.72	4462.82	.7853
" "	13.34	1400	102	86.54	4351.51	.7893
" "	13.17	1450	101	88.75	4441.35	.8034
" "	14.40	1200	107.8	78.40	3823.42	.7716
" "	13.07	1150	99	69.00	3637.22	.7685
	13.08	850	10.2	52.84	2963.38	.7177

Retest of the same, having cut the wings A of gates off. This change was made for the purpose of ascertaining whether those wings had an injurious effect upon the efficiency of the wheel when the gates were opened in full.

Whole Gate.	13.02	1750	102.5	108.63	5829.43	.7450
" "	13.19	1800	102	111.27	5852.72	.7631
" "	13.20	1850	100	112.12	5862.04	.7671
" "	13.31	1700	106.5	109.72	5806.15	.7517
" "	13.17	1900	98	112.84	5876.05	.7721
Part Gate.	14.15	1700	107	110.24	5383.01	.7663
" "	13.14	1700	98.5	101.48	5233.57	.7814
Whole Gate.	13.10	2000	92	111.51	5946.20	.7577

Hercules Wheel.

Holyoke Machine Co., Holyoke, Mass.

48-inch wheel.

Data below for one minute. Multiply revolutions by 20. Jan. 10, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate 20½ inches.	11.32	4400	000	000	8151.87	0000
" " " "	11.04	2600	84.5	133.15	8041.76	.7941
" " " "	11.47	2700	82.5	135.00	8122.32	.7767
" " " "	11.40	2800	78.3	132.87	8151.87	.7569
" " " "	11.45	2900	75.2	132.17	8180.04	.7472
" " " "	11.78	2600	89.5	141.03	8122.32	.7604
" " " "	11 74	2650	93.2	149.68	8145.96	.8286
" " " "	11.74	2550	94.5	146.04	8111.38	.8119
" " " "	11.68	2750	81.5	135.83	8157.78	.7547
Gate open 19 inches.	11.13	2750	78.3	130 50	7892.70	.7866
" " 18 "	11.70	2650	81.5	130.89	7750.30	.7643
" " 17 "	11.49	2600	78.5	123.69	7456.50	.7644
" " 17 "	11.54	2550	80	123.63	7433.75	.7631
" " 17 "	11.62	2500	83.5	126.51	7439.67	.7748
" " 16 "	11.20	2300	81.8	114.02	7000.30	.7700
" " 15 "	11.45	2100	87	110.72	6721.00	.7619
" " 15 "	11.41	2200	83.2	110.93	6764.60	.7610
" " 14 "	11.62	2100	85.7	109.07	6493.63	.7654
" " 14 "	11.68	2150	85	110.75	6541.40	.7674
" " 13 "	11.69	2100	83	105 63	6236.89	.7672
" " 12 "	11.60	1900	82.5	98.2	5841.73	.7659
" " 11 "	11.25	1750	80	84 84	5352.88	.7459
" " 11 "	11.47	1750	81	85.90	5368.15	.7387
" " 10 "	11.00	1500	82	74.54	4852.87	.7394
" " 9 "	11.70	1300	88.5	69.72	4463.90	.7068
" " 9 "	11.77	1350	85.5	69.95	4536 06	.6937
" " 9 "	11.70	1400	84	71.27	4574.69	.7050

Hercules Wheel.

Holyoke Machine Co., Holyoke, Mass.

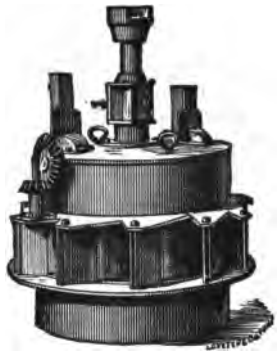
15-inch wheel.

Data below for one minute. Multiply revolutions by 10. March 5, 1880.

Gate Opened.	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate,	17.90	575			1172 22	
" "	17.94	250	375.5	28.41	1048.13	.8000
" "	17.92	275	356.5	29.71	1059.33	.8294
" "	17.90	300	327.5	29.77	1068.55	.8241
" "	17.90	325	298	29.65	1080.51	.8121
" "	17.86	275	356	29.66	1061 73	.8281
Part Gate.	17.88	275	345	28.75	1036.27	.8215
" "	17.86	270	346	28.30	1029.51	.8148
" "	17.87	265	352	28.26	1022.76	.8185
" "	17.86	260	356.5	28.28	1019.31	.8226
" "	17.86	250	375	28.39	1017.71	.8269
" "	17.86	250	355.5	26.93	987.54	.8084
" "	17.85	250	346	26.21	962.58	.8076
" "	17.90	245	347.5	25.79	954.30	.7993
" "	17.89	240	352	25.60	951.00	.7966
" "	17.85	235	356.5	25.38	946.05	.7957
" "	17.90	235	345	24.56	918.11	.7912
" "	17.91	230	353	24.60	911.57	.7978
" "	17.88	225	357.5	24 37	905.04	.7974
" "	17.95	225	343.5	23.42	880.68	.7848
" "	17 96	210	356	22.65	866.15	.7708
" "	17.97	200	351.6	21.30	827.14	.7586
" "	18.00	195	357.5	21.12	811.85	.7652
" "	18.01	195	343	20 26	796.06	.7429
" "	17.98	185	354	19.84	777 22	.7517
" "	18.02	180	360.5	19.66	770.98	.7493
" "	18.04	175	348.5	18.48	738.38	.7346
" "	18.06	170	354	18 23	730.68	.7314
" "	18.05	165	362.5	18.12	727.61	.7303
" "	18 07	160	350	16.96	689.46	.7207
" "	18.08	155	354.5	16.65	684.92	.7118
" "	18.10	145	353.5	15.53	641.44	.7082
" "	18.10	140	355	15.06	659.34	.6681
" "	18.15	130	348.5	13.72	587.09	.6817

Royer Wheel.

24-inch wheel, sent by R. R. Royer, Ephrata, Pa.

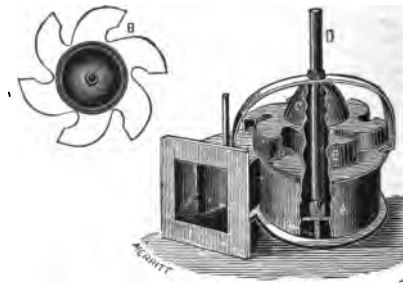


After the test of the first wheel, Mr. Royer returned home and prepared the one here reported.

Data below for one minute. Multiply revolutions by 10. March 9, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.86	655	000	000	978.04	000
" "	17.79	325	235.7	23.03	890.33	.7698
" "	17.76	350	227	24.07	904.95	.7929
" "	17.74	375	212.5	24.14	918.00	.7848
" "	17.70	400	198.5	24.06	929.47	.7744
" "	17.69	425	185.5	23 89	931.97	.7678
" "	17.70	340	229.5	23.64	901.69	.7843
" "	17.70	350	226.5	24.02	904.95	.7939
" "	17.69	360	222.5	24.27	908.21	.8000
" "	17.73	370	217.5	24.38	913.11	.7974
Part Gate.	17.73	370	215	24.10	918.00	.7839
" "	17.77	370	207.6	23.27	922.91	.7512
" "	17.80	360	215	23.45	922.91	.7733
" "	17.82	350	219.5	23.28	920.64	.7614
" "	17.84	350	206	21.84	909.84	.7124
" "	17.86	330	219.5	21.95	904.95	.7191
" "	17.90	300	215.7	19.60	680.61	.6434
" "	17.92	290	223	19.59	869.32	.6658
" "	17.93	250	225	17.01	815.05	.6299
" "	17.97	270	212.5	17.38	818.18	.6258
" "	17.98	250	187	14.16	769.47	.5418
" "	18.01	225	207.5	14.14	750.83	.5536
" "	18.02	215	216	14.07	746.19	.5541
" "	18 03	150	216	9.81	640.16	.4485
" "	18.13	145	224	9.84	632.75	.4541
" "	18.17	125	201	7.61	574.35	.3861
" "	18.17	115	209	7.23	567.16	.3740
" "	18.17	105	217	6.60	562.85	.3417
" "	18.23	75	191	4.34	478.59	.2630
" "	18.25	60	210	3.82	467.64	.2370
" "	18.27	50	222	3.37	462.18	.2113

Cyclonic Turbine.



More than ordinary pains was taken to obtain a decisive trial of this device, not from any belief in its superior efficiency, but because *cyclonic* minds, filled with *vorticose* ideas, are far more abundant than is generally realized, not only with the illiterate but quite as plentifully with the educated, the turbine user as well as builder. The cyclone, the whirlpool and centrifugal force have been harped upon in connection with turbine building since the conception of that business,—Uriah A. Boyden and the author of the cyclonic alike trying to profit thereby, to gain something from nothing. It should be plain to any level headed person that to produce a centrifugal force of one hundred pounds, a somewhat greater force must be expended to do it. Were the reverse the case, then "perpetual motion" would not only be possible, but would be very philosophical. The following explanation and description is by the author:

The laws that govern the action of this wheel, as its name implies, is copied from Nature, and is founded on the principles and laws that govern the rotary motion of the Cyclone—the great motor engine of our atmosphere. It is a well known fact in meteorology, that all storms, from the smallest whirlwind to the most extended cyclone, are translated along their course in a rapid vorticose motion, revolving around its axis, which is the point of lowest barometer. Immediately the vapor ladened air rushing along the earth's surface from points of high barometer, rise in spirals till they reach the cooler currents of the upper atmosphere, and there rapidly condense into clouds and rain, setting free the latent heat produced by condensation and greatly expanding the surrounding atmosphere and correspondingly increasing the point of low barometer. This rapid rotary motion calls into play the centripetal and centrifugal forces, and they, acting almost equally in apposite directions, and on both sides of the whirling air, it escapes spirally upwards with the power of both forces combined. It is the upward, twisting vorticose motion that makes the tornado the most destructive engine that comes within our experience, and as nature ever follows the line of least resistance, so it must be the most perfect and powerful mechanical contrivance with which we are acquainted—air and water in motion being governed by the same laws, with the exception that air is compressible and elastic.

In order to meet the differences, I have made the upper part of my wheel a large air chamber, then, as the water comes up into the wheel, instead of striking an iron plate, it strikes a column of confined air, and by the force of elasticity, it is thrown back upon the wheel without loss of power and escapes horizontally at the perimeter of the wheel—thus doing away with most of the impact and friction which seems to be a necessity to most other wheels. The claims that I have got allowed are, first, the air chamber, which is described as spherical, surmounting the wheel; second, a scroll shaped flume, with a central aperture through the top plate corresponding to one in the lower section of the wheel. The water enters the flume and is made to assume a vortical or cyclonic motion before it reaches the wheel, so that the wheel does not have to expend the power in changing a direct motion of the water column to a rotary or spiral one, but it gains in power from the application of the cyclonic motion, which the water has gained in passing through the flume, so that the wheel gets not only the head pressure but that due to the acquired centrifugal motion. The value of this wheel seems to be, first, in rapid whirlpool motion before it touches the wheel, and consequently does not have to perform that labor; second, its great velocity of revolution; third, the water coming in at the center and flowing outward makes the most of centrifugal force, which force is additional to head pressure, and will increase in proportion to the square of its velocity; fourth, a small wheel will do as much work as others two or three sizes larger, because the pressure, being greater, will discharge more water through the same vent with corresponding power.

24-inch wheel; six outlets, each 2⅞ inches square,

Data below for one minute. Multiply revolutions by 10. March 10, 1880.

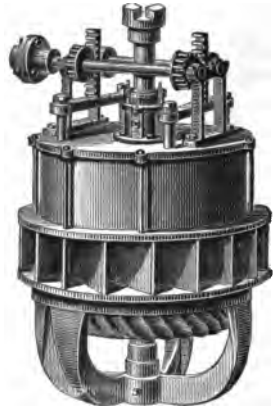
Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.10	200	000	0.00	307.20	000
" "	16.98	50	380	5.75	459.87	.3900
" "	17.03	75	299	6.70	428.46	.4861
" "	17.02	100	204	6.18	392.29	.4901
" "	17.00	60	352	6.40	443.41	.4495
" "	17.00	70	321.5	6.81	437.96	.4842
" "	17.00	80	288.5	6.99	425.77	.5113
" "	17.00	90	252.5	6.88	409.61	.5231
" "	17.00	85	266.5	6.86	406.93	.5250
" "	17.00	85	247	6.36	384.36	.5153
" "	17.00	75	290	6.59	402.92	.5094
" "	17.00	65	323.5	6.37	420.38	.4719
" "	17.00	59	195	2.95	268.93	.3416

Another test of same wheel, the outlets being enlarged to 2⅞ inches square.

Whole Gate.	16.93	230	000	0.00	416.31	000
" "	16.80	75	322.5	7.32	564.50	.4086
" "	16.80	85	289.5	7.45	555.81	.4224
" "	16.83	95	262	7.54	522.86	.4537
" "	16.84	105	235.5	7.49	508.69	.4630
" "	16.80	100	246.5	7.46	515.76	.4558
" "	16.82	90	278	7.58	534.23	.4466

Hunt Wheel.

Sent by R. Hunt Machine Co., Orange, Mass.



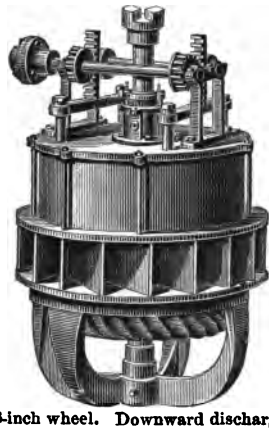
36-inch wheel. **Downward and outward discharge.**

Data below for one minute. Multiply revolutions by 15. May 19, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.73	1610	000	000	2431.00	000
" "	17.75	800	179	65.09	2399.36	.8091
" "	17.78	820	176.5	65.78	2396 20	.8174
" "	17.71	840	174.5	66.62	2402.52	.8290
" "	17.74	860	170.5	63.65	2418.32	.8226
" "	17.73	880	169	67.60	2424.65	.8324
" "	17.69	900	166.5	68.11	2434 16	.8374
" "	17 69	920	164	68.58	2450.02	.8376
" "	17.68	940	161.5	69.00	2459.55	.8401
" "	17.69	960	160	69.81	2469.09	.8161
" "	17 70	980	156	69.49	2481.94	.8374
" "	17.67	1000	154.5	70.22	2497.79	.8425
" "	17.66	1025	150.5	70.11	2507.37	.8382
" "	17.67	1050	148	70.63	2513.77	.8419
" "	17.68	1100	139.5	69 75	2513.77	.8309
Part Gate.	18.34	200	148.6	13.50	1167.94	.3337
" "	18.20	300	165	25.53	1473.79	.5639
" "	18.20	350	152.5	24.26	1498.56	.4709
" "	18 07	500	151.5	34.43	1781.38	.5663
" "	17.94	700	143.3	45.56	2044.46	.6576
" "	17.90	700	150	47.72	2086.79	.6763
" "	17.82	850	141.2	54.65	2260.65	.7169
" "	17.79	850	146	56.40	2298.97	.7304
" "	17.79	850	152.5	59.13	2352.15	.7481

Hunt Wheel.

Sent by R. Hunt Machine Co., Orange, Mass.



36-inch wheel. Downward discharge.

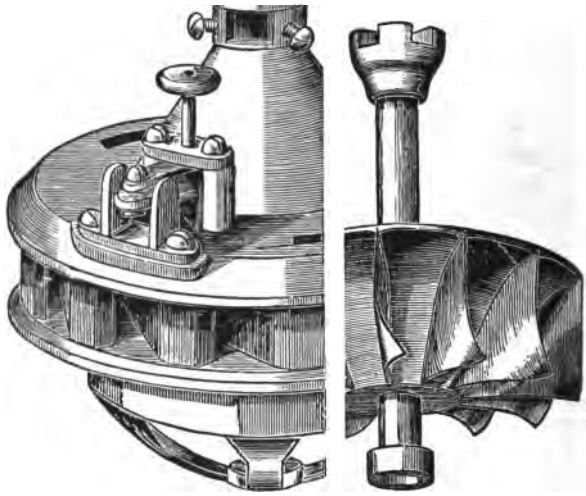
This wheel was made from the same patterns as the one upon the opposite page, but the hoop extended down to the bottom of the bucket, completely closing the outward discharge. The shaft of each wheel was extra heavy, or of large diameter, as they were made to work under high heads.

Data below for one minute. Multiply revolutions by 15. May 20, 1880.

Gate opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.18	1700	000	000	2568.23	.000
" "	17.65	850	165	63.75	2283.40	.7998
" "	17.65	875	162.5	64.63	2305.21	.8410
" "	17 61	900	159	65.04	2317.69	.8437
" "	17.58	925	155.5	65 38	2320.82	.8484
" "	17.60	950	150.5	64.97	2336.47	.8363
" "	17.58	975	149.5	66.25	2342.74	.8516
" "	17.58	1000	145.5	66.10	2355.29	.8452
Part Gate.	18.27	200	174	15.81	1147.42	.3993
" "	18.27	250	162 5	17.55	1204.10	.4223
" "	18.26	300	153	20.16	1235.34	.4732
" "	18.15	400	160	29.09	1498.56	.5662
" "	18.15	450	150	30.68	1528.98	.5854
" "	17.99	700	134	42.63	1880.66	.6670
" "	17.98	600	154.5	42.13	1851.22	.6701
" "	17.96	650	144	39.51	1874.78	.6212
" "	17.86	750	157 5	51.64	2089.82	.7325
" "	17.68	875	149 6	59.50	2267 89	.7874

Mercer's Reliable Turbine.

24-inch wheel, sent by Mercer & Stinman, Lancaster, Pa.



Downward discharge. Outside register gate.

Data below for one minute. Multiply revolutions by 10. May 29, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic feet	Per Cent.
Whole Gate.	18.28	775	000	000	1028.77	000
" "	18.24	350	211.6	22.42	998.95	.6514
" "	18.31	360	209.5	22.85	1001.43	.6449
" "	18.31	370	206.7	23.17	1001.43	.6690
" "	18.30	380	204.5	23.54	1003.91	.6784
" "	18.30	390	201.5	23.81	1006.39	.6845
" "	18.29	400	200	24.24	1008.87	.6954
" "	18.29	410	198.5	24.66	1011.35	.7058
" "	18.28	420	193.5	24.62	1013.87	.7033
" "	18.29	430	189	24.62	1016.32	.7012
Part Gate.	18.22	375	195	22.15	961.56	.6694
" "	18.23	375	192.5	21.87	947.34	.6686
" "	18.36	325	198.7	19.56	896.45	.6292
" "	18.34	275	201.5	16.79	839.22	.5775
" "	18.25	250	210.5	15.94	836.86	.5525
" "	18.50	190	207	11.91	730.07	.4668
" "	18.52	175	212	11.24	723.23	.4443
" "	18.57	150	225	10.22	698.31	.4173
" "	18.71	115	197	6.86	555.72	.3302
" "	18.71	100	212.5	6.44	551.46	.3304

Rechard Wheel.

24-inch wheel, sent by George F. Baugher, York, Pa.

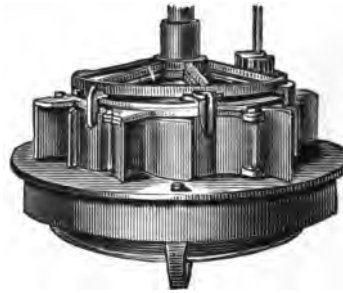
The results below show this wheel to be the most economical in the use of water at about three-fourths discharge; and Mr. Baugher takes the very novel course of tabling the capacity of his wheels at that point, thus insuring the purchaser not only the full power represented in the table, but a surplus for emergencies.

Data below for one minute. Multiply revolutions by 15. June 8, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	18.03	660	000	000	1749.33	000
" "	18.05	300	280.5	38.25	1669 66	.6719
" "	18.05	325	269	39.73	1678.15	.6944
" "	18.05	350	252	40.09	1686.64	.6972
" "	18.04	375	234	39.88	1703.67	.6870
" "	18.00	400	215	39.00	1712.20	.6700
" "	18.04	340	257	39.71	1689.48	.6898
" "	18.02	360	244.5	40.00	1692.31	.6943
" "	18 02	370	235.5	39.61	1695.15	.6865
Part Gate.	18.18	325	247	36.48	1356.80	.7829
" "	18.22	300	255	34.77	1288.13	.7844
" "	18.21	325	236.5	34.93	1293.38	.7851
" "	18.26	300	255.5	34.84	1192.19	.8481
" "	18.28	275	253	31.62	1153.92	.7937
" "	18.34	250	253 5	28.80	1070.96	.7763
" "	18.38	225	253.5	25.92	977.65	.7639
" "	18.39	225	248	25.21	960.73	.7555
" "	18.41	225	244.5	25.01	946.29	.7100
" "	18.46	185	251.5	21.15	851.59	.7123
" "	18.46	200	240	21.81	856.26	.7305
" "	18.52	150	250	17.04	728.26	.6689
" "	18.51	150	247.5	16.87	721.57	.6687
" "	18.55	150	233	15 88	666.43	.6800
" "	18.62	100	243.5	11.06	555.61	.5662
" "	18.61	80	257	9.34	534 91	.4968
" "	18.67	80	224	8.14	452.20	.5104

The Economical Turbine.

24-inch wheel, sent by S. Martin, York, Pa.



This turbine consisted of an upper plain downward discharge wheel above one of an outward discharge. The builder declined to have a test made of the upper wheel alone.

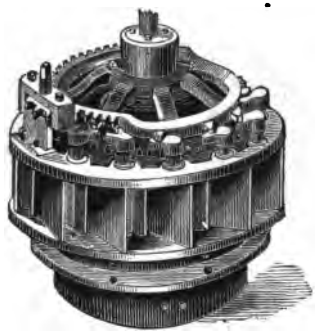
During this test, the area of aperture was 102 square inches.

Data below for one minute. Multiply revolutions by 10. June 15, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic feet	Per Cent
Whole Gate.	18.29	485	000	0000	752.36	000
" "	18.26	200	244.5	14.81	788.68	.5446
" "	18.25	210	234	14.89	787.09	.5489
" "	18.25	220	225	15.00	785.50	.5527
" "	18.27	230	215.5	15.02	783.91	.5552
" "	18.27	240	206	14.98	780.74	.5560
" "	18.27	250	194.2	14.71	777.58	.5482
Part Gate.	18.58	50	234.3	3.55	371.10	.2726
" "	18.55	70	205.5	4.35	368.46	.3369
" "	18.53	100	203	6.15	415.23	.4232
" "	18.51	95	210	6.05	424.94	.4072
" "	18.49	125	201.5	7.63	478.63	.4666
" "	18.48	120	209	7.60	481.43	.4522
" "	18.44	140	209.5	8.88	524.00	.4866
" "	18.41	160	210	10.18	570.30	.5134
" "	18.41	170	197.5	10.17	573.24	.5102
" "	18.41	165	205.5	10.27	571.77	.5154
" "	18.39	190	204.7	11.78	623.57	.5438
" "	18.34	210	198.5	12.63	656 70	.5552
" "	18 35	205	204.5	12.70	659.73	.5554
Second test of same wheel, area of aperture being reduced to 72 square inches.						
Whole Gate.	18.31	200	231.2	13 12	685.66	.6608
" "	18.31	210	222.5	13.10	681.07	.6007
" "	18.32	220	212.5	11.37	682.60	.6195
" "	18.33	230	204	11.86	682.60	.6198
" "	18.33	250	184	9.75	684.13	.5872
Part Gate.	18.33	215	201.5	13.12	638.58	.6134
" "	18.34	210	206	13.10	634.07	.6064
" "	18.39	175	214.5	11.37	590.87	.5541
" "	18.40	190	206	11.86	582.04	.5864
" "	18.44	150	214.5	9.75	521 08	.5372
" "	18.46	160	206	9 98	510.49	.6607
" "	18.52	125	194	7.34	431.57	.4862
" "	18.54	115	207	7.21	424.74	.4848
" "	18.61	65	196	3.86	321.72	.3413
" "	18.61	60	202	3.67	320.44	.3558

Stowe Wheel.

24-inch wheel, sent by E. W. Roff, Newark, N. J.



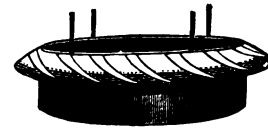
The claim for merit in this combination is upon the arrangement of gates, which open two at a time, up to sixteen in all. The plan of closing a part of the chutes or buckets of a turbine, for the purpose of using the water economically with a partial supply or at "part gate," has been tried by all of our noted turbine builders, and is still a favorite idea with amateurs or inexperienced persons interested in such matters. Walter S. Davis, of Warner, N. H., patented a plan nearly identical with that of the Stowe about 1870. J. B. Case, of Bristol, Ct., also, at about the same time, patented a plan the same in principle, though differing in detail.

Data below for one minute. Multiply revolutions by 10. June 17, 1880.

	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
16 Gates Opened. . . .	17.85	755	000	0000	1429.48	000
" " " . . .	18.00	340	276	28.43	1137.77	.7350
" " " . . .	18.08	350	274	29.06	1139.52	.7466
" " " . . .	18.05	360	269	29.34	1150.00	.7484
" " " . . .	18.04	370	267	29.90	1158.76	.7574
" " " . . .	18.04	380	265	30.51	1167.54	.7669
" " " . . .	18.05	390	260	30.72	1176.33	.7556
" " " . . .	18.05	400	255.5	30.97	1188.66	.7639
" " " . . .	18.02	410	253.5	31.49	1195.73	.7739
" " " . . .	18.01	420	247.5	31.50	1202.81	.7700
" " " . . .	18.02	430	245	31.92	1213.44	.7729
" " " . . .	18.01	450	238	32.45	1224.06	.7795
" " " . . .	17.97	475	231	33.25	1256.05	.7800
" " " . . .	17.95	500	221	33.45	1265.21	.7799
" " " . . .	17.94	550	202	33.66	1292.21	.7678
10 " " . . .	18.22	300	249.3	22.66	942.03	.6989
" " " . . .	18.17	325	238	23.43	968.68	.7047
8 " " . . .	18.33	225	244	16.63	723.55	.6592
" " " . . .	18.31	235	240	17.09	744.09	.6642
" " " . . .	18.31	245	233.5	17.33	753.45	.6650
6 " " . . .	18.46	175	233	12.35	561.98	.6303
" " " . . .	18.43	165	236	11.80	563.43	.6017
4 " " . . .	18.60	100	224	6.78	363.48	.5309
" " " . . .	18.60	90	231	6.30	362.17	.4952
" " " . . .	18.61	85	234.2	6.03	359.57	.4770
2 " " . . .	18.18	50	210	3.18	203.66	.4546

Hard Working Gate.

Risdon Wheel.



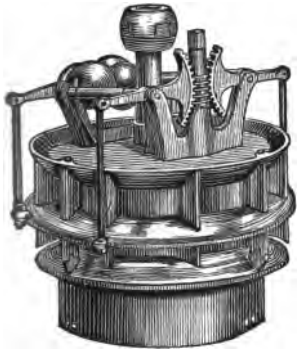
Gate.

To ascertain the comparative efficiency of a plain cylinder gate at different stages of gate opening, the following experiments were made: A 36-inch Risdon turbine was selected for the purpose. It was one of the best, and from the same patterns the 90 per cent. wheels reported of that make were made. The gate hoisting rods and geared levers were changed to the plan to be seen upon the Hunt wheel reported upon another page. As the gate raised to open, it worked the other side up from what it is illustrated here and the four hoisting rods were connected to what is represented as the bottom, running up, and in no way obstructing the chutes. In this condition the wheel was carefully tested.

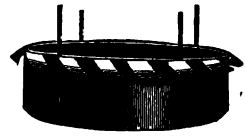
Data below for one minute. Multiply revolutions by 15.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.19	700	170.6	54.28	1966.76	.8033
" "	18.19	725	166	54.90	1972.76	.8070
" "	18.19	750	161.3	54.98	1970.76	.8120
" "	18.18	775	155.6	54.80	1970.76	.8099
" "	18.18	800	150.3	54.65	1979.76	.8039
" "	18.18	740	163	54.82	1966.76	.8118
" "	18.18	760	158.2	54.65	1953.76	.8110
Part Gate.	18.19	760	152.1	52.54	1901.16	.8044
" "	18.20	745	155	52.48	1901.16	.8030
" "	18.22	725	159.5	52.5[illegible]	1898.19	.8045
" "	18.25	725	151	49.76	1824.45	.7914
" "	18.27	700	156.5	49.79	1818.59	.7934
" "	18.27	675	162.5	49.85	1818.59	.7944
" "	18.30	665	154.5	46.70	1728.38	.7817
" "	18.31	645	158	46.32	1722.60	.7775
" "	18.32	625	163.7	46.50	1713.96	.7840
" "	18.37	600	154.5	42.13	1608.25	.7550
" "	18.38	585	158.2	42.06	1602.59	.7560
" "	18.38	570	162.5	42.10	1605.42	.7654
" "	18.42	525	155.5	37.10	1476.72	.7222
" "	18.42	510	158.8	38.81	1476.72	.7164
" "	18.44	495	162.8	36.63	1479.49	.7180
" "	18.49	450	152.5	31.19	1326.84	.6730
" "	18.49	435	155.5	30.74	1324.15	.6709
" "	18.50	415	161.2	30.40	1321.47	.6583
" "	18.57	350	156	24.81	1160.69	.6095
" "	18 57	340	159.5	24 65	1160.69	.6055
" "	18.57	330	160.5	24 07	1155.52	.5939
" "	18.62	300	143.7	19.59	983.26	.5666

Easier Working Gate.



Risdon Wheel.



Gate.

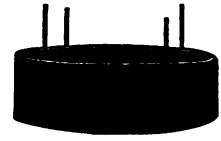
Retest of the same wheel, the flange of the gate having been cut away about half the length of the chutes, as represented above.

Data below for one minute. Multiply revolutions by 15.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18.21	700	171	54.40	1962.74	.8058
" "	18.20	725	165.7	54.60	1965.53	.8080
" "	18.21	750	162	55.22	1968 52	.8149
" "	18.21	775	155.2	54.67	1965.53	.8086
" "	18.21	800	149.7	54.43	1977.49	.8003
" "	18 21	740	162.5	54.65	1971 51	.8058
" "	18.20	760	158.5	54 75	1988.48	.8081
Part Gate.	18.23	760	151.5	52.33	1911.94	.7950
" "	18.22	745	154.3	52.25	1908.98	.7952
" "	18.23	725	159.5	52.56	1906.02	.8008
" "	18.23	725	150.5	49.59	1835.31	.7838
" "	18.23	700	155.3	49.41	1829.39	.7832
" "	18.26	675	160.5	49.24	1828.48	.7817
" "	18.30	665	151.3	45.73	1727.80	.7656
" "	18.29	645	156	45.73	1719.16	.7700
" "	18.31	625	160.6	45.62	1716.28	.7685
" "	18.35	600	151	41.18	1613.65	.7363
" "	18.34	585	155.2	41.26	1605.18	.7420
" "	18.35	570	158	40.91	1605.18	.7352
" "	18.34	555	163	41.12	1601.56	.7413
" "	18.40	510	152.6	35.37	1482.40	.6865
" "	18.40	495	158.7	35.70	1479.64	.6943
" "	18.40	480	163	35.56	1476.88	.6928
" "	18.46	430	154.6	30.11	1335.51	.6466
" "	18.46	415	158.5	29.89	1330.15	.6401
" "	18.47	400	163.5	29.72	1327.47	.6403
" "	18.53	340	155.6	24.04	1169.65	.5739
" "	18.54	325	160	23.63	1167.07	.5781
" "	18.53	315	163	23.33	1164.49	.5726
" "	18.60	260	155	18.31	1000.06	.5211

Easy Working Gate.

Risdon 36-inch wheel.



Gate.

A third test of the same wheel, the flange of the gate having been cut entirely away, leaving a plain cylinder gate.

Data below for one minute. Multiply revolutions by 15.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	18 23	700	177	56.31	2120.25	.7713
" "	18.24	725	171.2	56.48	2139.46	.7662
" "	18.25	750	165.6	56.75	2139.46	.7695
" "	18.24	775	160 5	56.54	2136.39	.7681
" "	18.22	800	154.5	56.18	2136.39	.7643
" "	18.23	740	168	56.50	2139.46	.7669
" "	18.23	760	163.7	56.41	2136.39	.7669
Part Gate.	18.24	760	156.5	54.06	2096 53	.7484
" "	18.26	745	161.5	54.68	2090.41	.7585
" "	18.24	725	165.6	54.27	2081.25	.7569
" "	18.26	725	155	51.07	2023.49	.7317
" "	18.27	700	161.5	51.38	2017.43	.7280
" "	18.26	675	166.6	51.12	2017.43	.7347
" "	18.28	665	157	47.45	1942.20	.7076
" "	18·30	645	158.5	46 46	1939.21	.6932
" "	18.23	625	166	47.17	1923.23	.7103
" "	18.30	600	155 5	42.40	1850.02	.6631
" "	18.31	585	158.5	42.14	1850.02	.6586
" "	18.31	570	163	42.23	1844.12	.6622
" "	18.31	555	166.2	41.92	1838.22	.6514
" "	18 36	510	157.7	38.55	1727.17	.6101
" "	18.38	495	164	36.90	1727.17	.6154
" "	18.37	480	167.5	36.54	1727.17	.6097
" "	18.42	430	158	31.18	1601.01	.5600
" "	18.42	415	162.5	30.65	1595.34	.5523
" "	18.42	400	167.5	30.45	1595.34	.5486
" "	18.48	340	160	24.72	1458.15	.4856
" "	18.47	325	165	24.37	1455.39	.4800
" "	18.48	315	167.6	23.96	1455.39	.4717
" "	18.55	260	156.6	18.51	1289.50	.4047
" "	18.54	245	162.5	18.09	1284.16	.4063
" "	18.54	230	167.2	17.48	1281 49	.3895
" "	18.62	150	164	11.18	1083	.2935
" "	18.64	140	166	10.56	1077.89	.2782

EXPERIMENTS

WITH

Gears, Belts and Draft Tubes.

[These experiments occupied the time from March 18 to April 23 inclusive.]

In presenting these results, it is not pretended that they exhaust the subjects, for such is far from being the case, as every change made, no matter how slight, caused a change in the rate of transmission. The best results obtained are given, while the conditions under which they were obtained were certainly quite as favorable as gears and shafting are likely to be placed in mills. The great loss in transmission through the spur gears was entirely unexpected, and the experiment was repeated at intervals, during several weeks, with substantially the same results at each repetition, and it would seem desirable to make a more exhaustive trial by trying a greater variety of gears of different make and relative proportion, and particularly of gears made from the same patterns, but of different brands of iron. There must be some discoverable cause why one gear will run without perceptible wear for years, when another, put in to replace it, cuts out in a day or two. So of water wheel steps, where two wheels, seemingly alike, placed in the same pit, with one the step lasts for years, while the other requires a new one monthly. Is there not some property in the iron that causes such different effects? At any rate, it is hardly worth while to spend time, brains and money in efforts to produce turbines and other engines of the highest efficiency, unless corresponding efforts are made to transmit a reasonable proportion of such efficiency.

To find the loss of power in transmission through gears, and the loss by use of draft tubes, the highest efficiency in each case must be compared with that of the 15-inch Victor wheel reported upon the next page.

Victor Turbine.

15 inches in diameter. Price, $350.

This wheel was in use several weeks to make the following gear, draft tube and belt experiments. The results below show the efficiency of the wheel. Data for one minute. Multiply revolutions by 10.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.98	310	323.2	30.36	981.15	.9111
" "	17.97	320	300.5	29.13	981.15	.8747
" "	17.97	290	348.5	30.62	974.47	.9258
" "	17.98	290	347.5	30.53	972.80	.9242
" "	18.00	280	355	30.12	969.47	.9139
" "	17.98	300	337.3	30.66	977.81	.9234
Part Gate.	17.99	300	331	30.09	972.80	.9102
" "	17.99	290	345	30.31	972.80	.9174
" "	18.00	300	334.5	30.40	972.80	.9191
" "	17.99	290	334	29.35	971.13	.8896
" "	17.99	275	339	28.25	962.82	.8634
" "	18.02	260	331.5	26.11	901.88	.8506
" "	18.03	250	338.5	25.64	897.00	.8394
" "	18.09	230	331.2	23.08	820.67	.8231
" "	18.09	225	339.5	23.14	808.53	.8376
" "	18.20	175	339	17.97	695.06	.7538
" "	18.38	105	334	10.62	482.59	.6345
" "	18.41	95	340	9.78	460.56	.6108

Re-test of the wheel some weeks later, several alterations having been made.

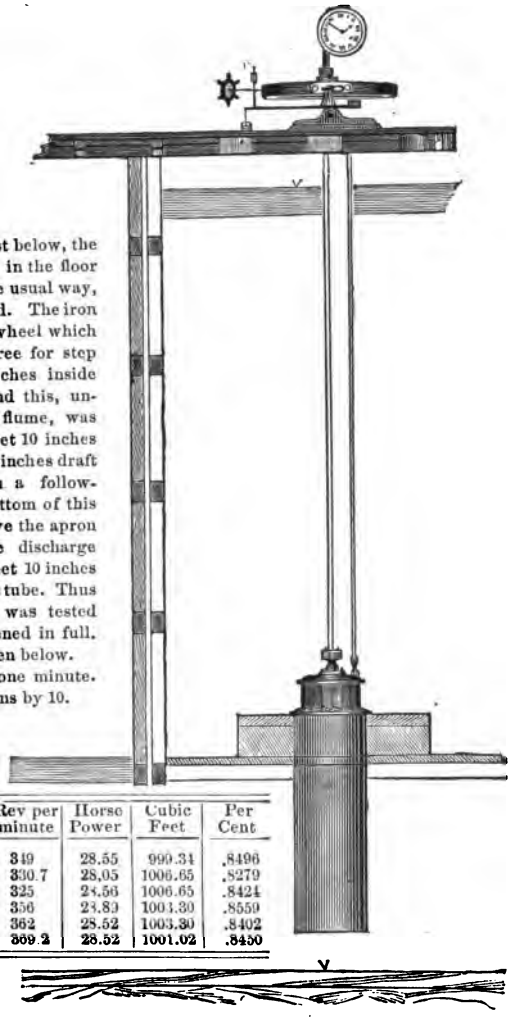
Whole Gate.	17.94	285	352	30.40	981.46	.9141

The results obtained from a 23-inch Boyden wheel, price $500, tested in the same place and under precisely the same conditions is here given. The Boyden wheel, however, had a sort of flanged gate specially fitted for the trial. With the ordinary gate, the results are shown in the lowest table. Made at Ames Works.

Best Whole Gate.	18.16	195	263.5	15.21	553.15	.8364
Part Gate.	18.14	155	263	12.35	477 27	.7551
" "	18.29	75	264	6.00	325.49	.5336
Whole Gate.	18.25	195	257.5	15.21	545.79	.8084
Part Gate.	18.33	75	259.5	5.87	380.63	.4973

Draft Tube in Backwater.

Experiment to determine whether a draft tube causes a loss of efficiency during backwater.

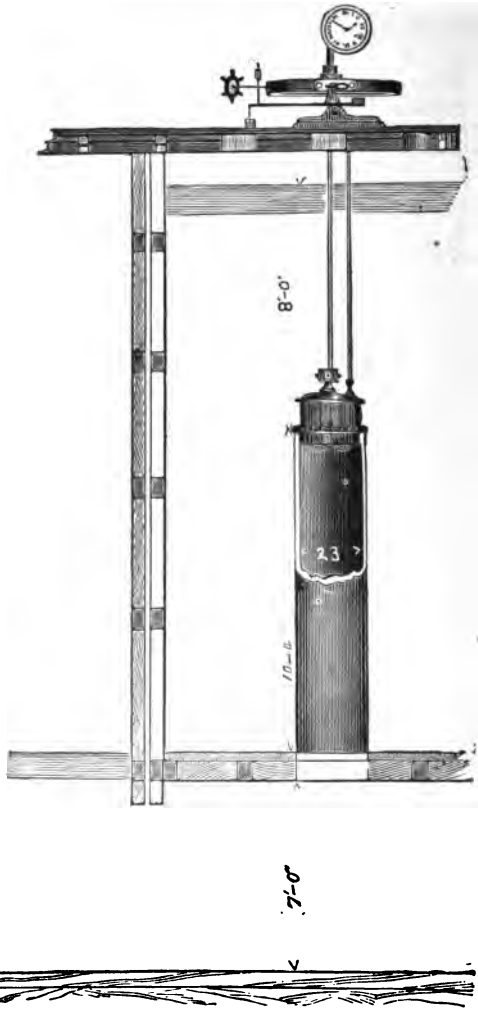


To make the test below, the **wheel was placed** in the floor **of the flume in the** usual way, **under the full head.** The iron **draft tube of the** wheel which **held the bridge-tree** for step **was about 21 inches** inside **diameter. Around** this, **underneath floor of flume,** was **placed a piece 6 feet** 10 inches **in length of the 23** inches draft **tube described on a** following **page. The bottom** of this **was 22 inches above** the apron **of wheel pit, the** discharge **being through 6 feet** 10 inches **of submerged draft** tube. Thus **placed, the wheel** was tested **with the gate opened** in full. **Results may be seen** below.

Data below for one minute. **Multiply revolutions** by 10.

Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
17.80	270	349	28.55	999.34	.8496
17.80	280	330.7	28.05	1006.65	.8279
17.81	290	325	28.56	1006.65	.8424
17.81	265	356	23.89	1003.30	.8559
17.83	260	362	28.52	1003.30	.8402
17.84	255	369.2	28.52	1001.02	.8450

Draft Tube Experiments.



In preparing for these tests, the wheel was placed 10 feet above the flume floor upon the top of a draft tube 23 inches inside diameter, 10 feet 4 inches in length. Results on opposite page.

DEPARTMENT OF THE INTERIOR, UNITED STATES PATENT OFFICE,
Washington, D. C., June 17th, 1880.

SIR: In reply to your letter of 14th inst., you are informed that the records of this office show that the first patent granted for "Draft Tube for Water Wheels" was issued June 28th, 1840, No. 1658. It appears to have been the invention of Zebulon and Austin Parker of Licking Co., Ohio. The patent was issued to Zebulon Parker and R. McKilby, administrator of Austin Parker, deceased.

Respectfully yours,

F. A. SEELEY, *Chief Clerk.*

JAMES EMERSON, Willimansett, Mass.

Tests of 15 inch wheel placed as shown on opposite page.

The wheel was far less steady during this trial than when placed at the bottom of the flume. As the tube was surrounded by 8 feet of water, of course there was no leakage of air.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.73	285	322	27.80	959.51	.8651
" "	17.77	295	307.5	27.48	957.85	.8548
" "	17.77	305	291.5	26.94	961.18	.8352
" "	17.79	270	345	28.22	954.52	.8799
" "	17.78	275	336.2	28.02	954.52	.8741
" "	17.79	280	326	27.66	961.18	.8369
" "	17.80	275	338.5	28.20	957.85	.8737

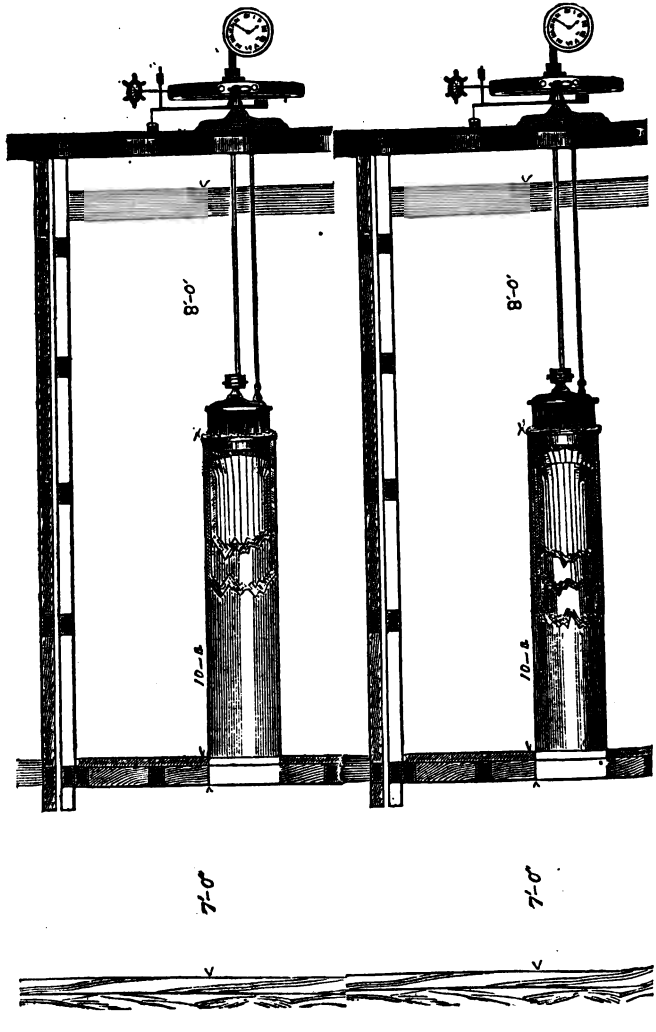
Test of the same, the lower end of draft tube being unsubmerged.

Whole Gate.	17.80	100	266	8.06		

Second test of the same draft tube taken several days later.

Whole Gate.	17.91	200	349.3	21.17	869.88	.7194
" "	17.87	230	356.2	24.82	937.09	.7848
" "	17.82	250	362	27 42	957.00	.8512
" "	17.81	260	354.5	27.93	967.12	.8585
" "	17.81	270	341.7	27.95	974.77	.8523
" "	17.79	280	325.5	27.62	983.75	.8356
Part Gate.	17.96	200	328.5	19.90	789.75	.7428
" "	17.95	190	340.7	19.61	783.43	.7383
" "	18.11	100	356.6	10 80	550.66	.5733
" "	18.11	110	345	11.50	549.22	.6122

The wheel was more difficult to control with brake than during the first trial. It took a long time to clear the tube of air. Quite a number of tests were taken before anything like the power due the head could be obtained, though they were not recorded.


8'-0"
10-8
7'-0"
8'-0"
10-8
7'-0"

Reduced Draft Tube.

Test with 19-inch draft tube.

During this test the wheel was placed at the top of the before mentioned 23-inch draft tube, that having been diminished in diameter by the insertion of a lining 2 inches in thickness, leaving the inside diameter of tube 19 inches in the clear, and 10 feet 4 inches in length as before; and, as before, about 8 feet of the head above the wheel.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	17.90	250	354	26.81	959.52	.8264
" "	17.88	260	337.5	26.57	961.18	.8185
" "	17.89	270	324.2	26.52	964.50	.8137
" "	17.89	280	309	26.21	966.17	.8029
" "	17 88	240	365	26.54	957.86	.8204
Test of the above arrangement the lower end of tube being unsubmerged.						
Whole Gate.		130	369	14.53		
" "		140	367	15.57		

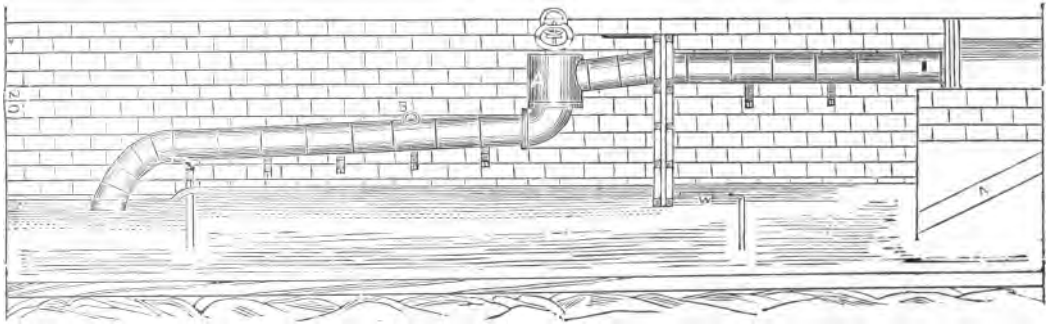
Draft Tube Again Reduced.

Test with 15-inch draft tube.

Continuation of the same arrangement of tubes as before, another lining having been inserted, leaving inside diameter of tube 15 inches; length, 10 feet 4 inches, as before.

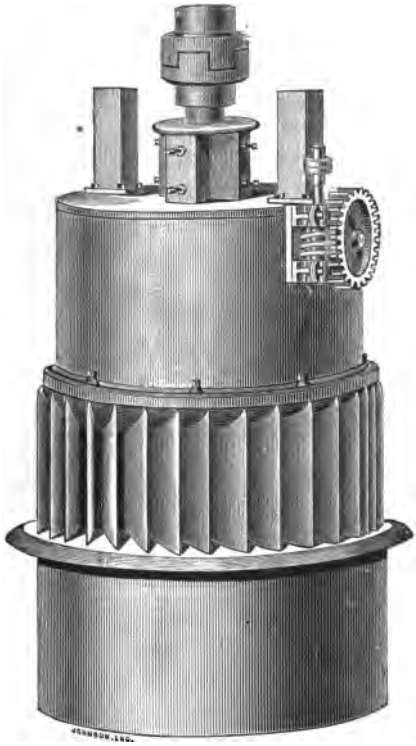
Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate.	17.88	200	376	22.81	890.78	.7584
" "	17.87	225	336	22.90	898.97	.7546
" "	17.85	250	296	22.42	905.53	.7339
" "	17.86	240	310.6	22.58	905.53	.7391
" "	17.86	230	324.5	22.61	902.25	.7429
" "	17.86	220	339.5	22.63	898.97	.7462
" "	17.86	210	355.5	22.62	894.05	.7500
" "	18.08	125	338 5	12.82	591.92	.6343
Gate open two-thirds. . .	18.24	70	322.5	6.84	415.42	.4779
" " one-half. . . .	18.24	65	329.2	6.48	415.42	.4527
" " one-half. . . .	18.24	60	338	6.14	411.37	.4333
Test with the lower end of draft tube unsubmerged.						
Whole Gate.		200	365	22.30		
" "		225	323	22.02		

Elevation of Testing Flume and Draft Tube.



The Draft tube represented above along the side of flume and over the measuring pit, was so constructed that the water passing through it might be discharged below the weir, in order to allow a continued use of the wheel, with which the experiments were made, to add to the power used in the Whiting Paper Mill, near by. As may be seen, the water enters the round iron trunk above the flume. This trunk is four feet in diameter and about fifty feet in length to the wheel case, A. From the wheel case, the draft tube four feet in diameter, descending one foot in forty, carries the discharge over the weir, a distance of about fifty feet from the wheel. A 27-inch Hercules wheel, having a plain unflanged cylinder gate, was first tested in the ordinary way in the testing flume—the wheel standing in the opening of the floor, marked W. The results may be seen in the upper table on the opposite page. In the same place, with twenty feet head, the wheel would give 104 h. p., and make about 193 revolutions per minute. After the test in the flume, the wheel was placed in the curb, A, and the brake was applied at the top of shaft fitted for the crown gear. The results given in the lower table on opposite page show the efficiency of that style of draft tube.

The Hercules.

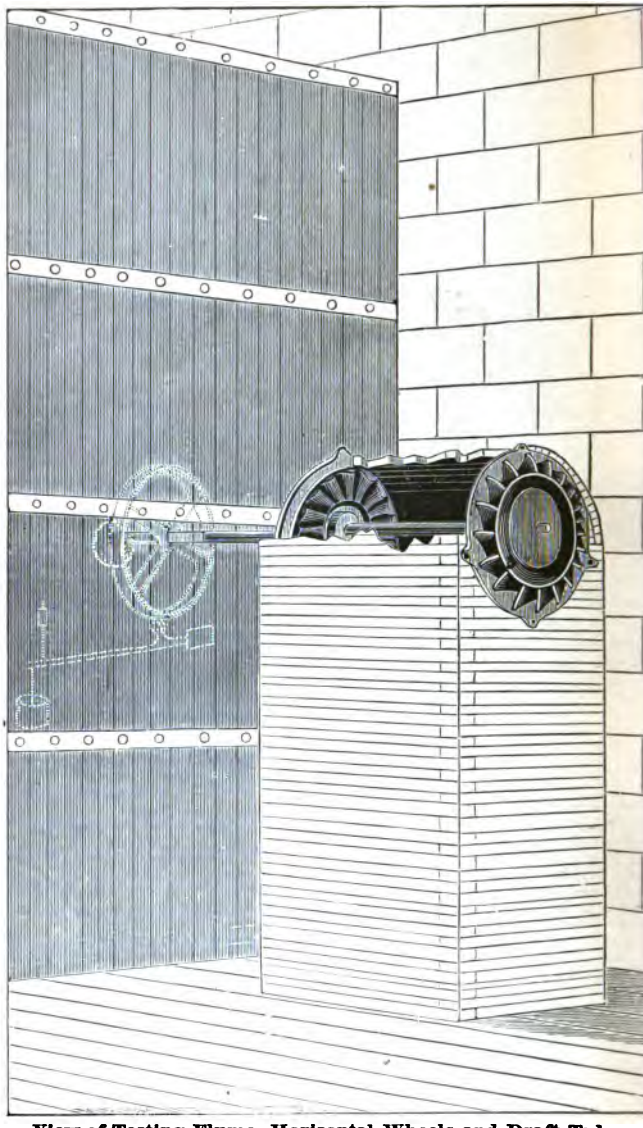


Test of wheel in flume in the ordinary way.
Data below for one minute. Multiply revolutions by 15. Dec. 6, 1879.

Gate opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet.	Per Cent
Whole Gate.	17.03	1000	177.3	80.59	3264.21	.7648
" "	17.13	1050	167.5	79.94	3288.37	.7514
" "	17.02	1100	157.5	78.75	3288.37	.7450
" "	17.15	950	190	82.04	3240.09	.7817
" "	17.16	900	199	81.41	3205.72	.7835
" "	17.16	975	182.5	80.88	3233.21	.7719
" "	17.16	925	194	81.56	3216.02	.7824

Test of wheel for power after it was placed in the wheel case, A, and previous to its being geared to the machinery in the mill near by.

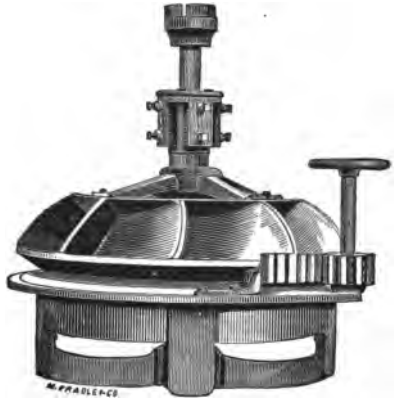
Whole Gate.	20.00	900	173	70.77	. . .	. . .
" "	20.00	850	184	71.09	. . .	. . .
" "	20.00	800	188	68.36	. . .	. . .



View of Testing Flume, Horizontal Wheels and Draft Tube.

Curtis Wheel.

Sent by Gates Curtis, Ogdensburg, N. Y.



The results in the table below were obtained from the test of a 35-inch wheel upon upright shaft in the usual way. The inside register gate had been left out, so the chutes were open in full and the water was applied by the head gates of testing flume.

Data below for one minute. Multiply revolutions by 15. Oct. 22, 1879.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	17.69	2225	000	000	3115.69	.0000
" "	17.77	900	193	78.95	2905.30	.8096
" "	17.77	1000	179	81.36	2935.63	.8258
" "	17.75	1100	165.5	82.75	2950.83	.8365
" "	17.74	1200	152	82.90	2981.29	.8300
" "	17.73	1300	138.5	81.82	3004.21	.8133
" "	17.75	1050	171.2	81.70	2954.63	.8248
" "	17.74	1150	159	83.11	2966.05	.8363
" "	17.80	100	273.5	12.43	2574.47	.0000

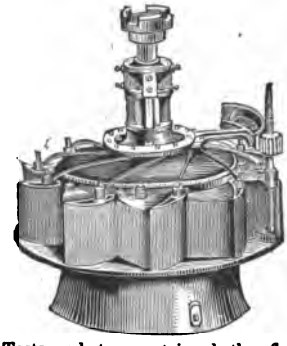
After the above test, the same wheel, with a left-hand mate of the same supposed efficiency, was fixed upon a horizontal shaft, then placed in the flume at the top of a square draft tube ten feet in height, as shown on the opposite page. The draft tube and fittings were furnished by Mr. Curtis, and upon the same scale that he had furnished for other wheels of the kind for mills. The dotted lines in bulk-head show the application of the brake for testing. The same may perhaps be more clearly seen in the illustration of Measuring Pit in the first part of this report.

Data below for one minute. Multiply revolutions by 20.

Whole Gate.	16.23	1500	141	128.18	5794.09	.7204
" "	16.38	1400	150.5	127.70	5779.76	.7141
" "	16.37	1450	145	127.42	5788.43	.6940
" "	16.37	1500	140.6	127.81	5817.38	.7089
" "	16.40	1350	151	126.81	5761.51	.7105
" "	16.39	1300	159.2	125.43	5738.27	.7161

New American Wheel.

30-inch wheel, sent by Stout, Mills & Temple, Dayton, Ohio.



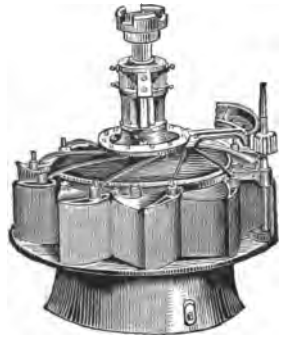
Tests made to ascertain whether flaring the ordinary draft tube of a turbine at the bottom adds to its efficiency. During this trial the water, in passing through the wheel, made a constant rumbling or humming sound, whether the wheel was running or held stationary by the brake.

Data below for one minute. Multiply revolutions by 15. July 2, 1880.

	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate 10½in. or 72 turns	17.75	1100	000	000	2504.00	000
" "	17.75	650	209.3	61.83	2389.50	.7735
" "	17.74	700	199	63.31	2424.32	.7793
" "	17.74	750	186.5	63.57	2478.42	.7655
" "	17.73	800	175.5	63.81	2539.27	.7523
" "	17.71	850	163	62.72	2574.71	.7284
" "	17.77	675	207.5	63.66	2430.66	.7803
" "	17.73	725	194	63.93	2478.42	.7703
Part Gate.	17.84	650	203	59.98	2267.22	.7852
" "	17.81	675	202	61.97	2354.82	.7823
" "	17.85	675	201.6	61.85	2329.69	.7874
" "	17.87	650	206.5	61.02	2261.00	.7997
" "	17.89	625	207.5	58.94	2202.14	.7922
" "	17.91	600	208.5	56.86	2113.18	.7954
" "	17.91	610	206.5	57.25	2128.44	.7951
" "	17.90	610	205.5	56.97	2116.23	.7962
" "	17.90	600	207 5	56.83	2091.86	.8044
" "	17.94	580	207.5	54.70	2013.23	.8017
" "	17.92	600	202	55.09	2031.30	.8012
" "	17.97	550	207.5	51.87	1914.68	.7980
" "	17.96	550	205	51.25	1896.82	.7963
" "	18.04	500	207	47.04	1759.40	.7861
" "	18.01	525	202	48.20	1794.24	.7904
" "	18.04	500	205	46.57	1727.66	.7912
" "	18.11	430	209.5	40.97	1561.16	.7673
" "	18.10	440	206.5	41.30	1577.00	.7661
" "	18.10	450	205.5	42.34	1589.21	.7793
" "	18.09	475	199	42.96	1613.56	.7792
" "	18.17	390	208	36.84	1443.91	.7434
" "	18.16	400	205.5	37.36	1427.51	.7631
" "	18.24	335	206	31.36	1234.86	.7372

The average efficiency from half to whole gate, .779

New American Wheel.



30-inch wheel.

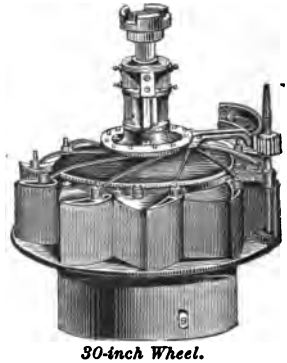
Retest of the wheel after slightly reducing its diameter, as it was found to have touched the curb during the former trial. As may be seen, this change raised the whole gate efficiency at the expense of that of the part gate.

Data below for one minute. Multiply revolutions by 15. July 7, 1880.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate 10¼ in or 72 turns	17.67	675	210.4	64 55	2487.94	.7774
" " " " "	17.64	685	208.5	64.92	2494.32	.7812
" " " " "	17.65	700	203	64.59	2507.07	.7727
" " " " "	17.63	715	201.5	65.46	2513.46	.7821
Gate open 8 1-16in. or 59 turns	17.67	700	200.5	63.79	2405.55	.7964
" " " " " "	17.71	675	203	62.28	2349.00	.7926
" " " " " "	17.72	650	209.5	61.90	2323.99	.7958
" " 7⅛ " 55 "	17.75	650	202 5	59.83	2286.62	.7804
" " " " " "	17.74	640	208.5	60.66	2268.01	.7988
" " " " " "	17.72	675	200	61.36	2299.06	.7976
" " 7 " 51 "	17.77	650	201.2	59,44	2212.41	.7990
" " " " " "	17.77	630	207	59.27	2200.12	.8027
" " 6½ " 47 "	17.81	625	204	57.95	2141.97	.8042
" " " " " "	17.80	645	198	55.02	2151.12	.7608
" " " " " "	17.81	600	206.7	56.37	2135.87	.7845
" " 5 15-16 " 43 "	17.85	575	205	53.58	2018.06	.7875
" " " " " "	17.85	560	208	52.94	2009.08	.7816
" " " " " "	17.84	600	201	54.81	2036.06	.7989
" " 5 5-16 " 39 "	17.92	525	206	49.15	1890.44	.7661
" " " " " "	17.90	545	204	50.53	1899.26	.7869
" " 4⅞ " 35 "	17 97	500	203	46.13	1765.26	.7700
" " " " " "	17.96	490	204	45.43	1759.50	.7611
" " " " " "	17.96	480	207	45.16	1750.86	.7604
" " 4½ " 31 "	18.03	465	197	41.63	1639.76	.7482
" " " " " "	18.04	450	203	41.52	1631.30	.7471
" " 3½ " 27 "	18.11	390	206	36.51	1453.89	.7358
" " " " " "	18.12	400	203	36.90	1473.00	.7319
" " 2 15-16 " 23 "	18.17	300	220	30.00	1251.00	.6988
" " " " " "	18.16	335	285.5	31.44	1292.99	.7089
" " " " " "	18.16	350	200.5	31.90	1293.00	.7192

Average, .771

New American Wheel.



30-inch Wheel.

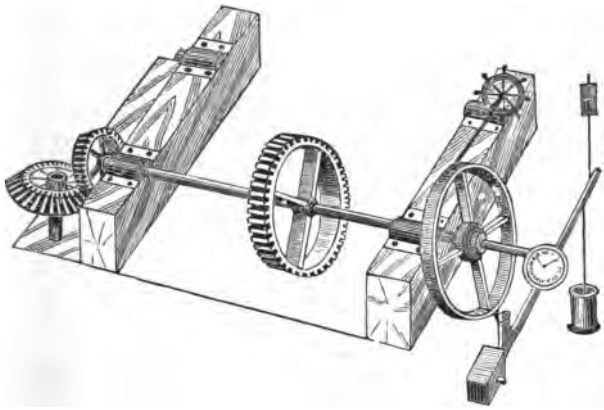
Retest of the same wheel after changing the flaring for a straight draft tube. The gate openings were the same through the three trials. The 10½ inches at whole gate means the extreme swing of gate, the openings at outer end of chutes being 7½ inches only; but the gate had to move the distance named to clear the openings. The averages are found by adding the thirty tests of each trial together and dividing by that number.

Data below for one minute. Multiply revolutions by 15. July 8, 1880.

	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent.
Whole Gate 10½in. or 72 turns	17.73	675	209.8	64.37	2491.16	.7715
" "	17.70	700	205.2	65.29	2500.72	.7809
" "	17.68	725	198.5	65.41	2513.48	.7794
" "	17.67	750	192.5	65.92	2545.04	.7759
Gate open 59 turns. . .	17.77	675	203.5	62.43	2355.41	.7900
" " 55 " . .	17.79	625	212	60.22	2252.75	.7950
" " " " . .	17.79	650	206.5	60.71	2258.93	.8000
" " " " . .	17.78	675	200	61.36	2289.92	.7979
" " 51 " . .	17.82	650	202	59.68	2225.00	.7969
" " " " . .	17.81	625	207.5	58.94	2194.25	.7984
" " 47 " . .	17.85	600	208.5	56.86	2136.19	.7895
" " " " . .	17.85	625	203.5	57.41	2145.33	.7937
" " " " . .	17.85	650	197	58.20	2154.48	.8012
" " 43 " . .	17.90	575	208	54.36	2015.49	.7978
" " " " . .	17.90	600	201.5	54.95	2151.48	.7923
" " 39 " . .	17.96	525	208	47.63	1885.29	.7760
" " " " . .	17.96	550	206.5	51.62	1899.79	.8009
" " " " . .	17.94	575	200	52.27	1952.93	.7900
" " 35 " . .	18.01	475	211	45.56	1751.52	.7647
" " " " . .	18.00	500	206	46.00	1786.09	.7574
" " " " . .	18.00	525	201	47.96	1806.35	.7810
" " 31 " . .	18.06	425	211.5	40.85	1599.41	.7483
" " " " . .	18.05	450	207.5	42.44	1632.08	.7629
" " " " . .	18.04	475	198	42.75	1666.00	.7531
" " 27 " . .	18.12	375	213.2	36.34	1454.85	.7299
" " " " . .	18.11	400	207.5	37.72	1484.90	.7426
" " " " . .	18.09	425	200	38.63	1509.60	.7489
" " 23 " . .	18.17	325	216.5	31.97	1308.32	.7119
" " " " . .	18.18	350	208	33.09	1328.49	.7253
" " " " . .	18.17	375	200	34.09	1363.11	.7287

Average, .774

Experiments with Gears.



Tests made for the purpose of ascertaining the loss of power in transmission through gears. To make these the brake, as shown above, was placed upon one end of a horizontal shaft, representing "Jack Shaft," the other end being connected to the turbine shaft in the usual way by bevel gears. These gears, shafts and fittings were generously furnished for the purpose by the Messrs. Poole & Hunt, of Baltimore, Md. Other gear makers were applied to but none of them seemed willing to submit their gears to such trial. Plain cast gears with unfinished surfaces were furnished. The workmanship of the gears, shafts and boxes was pronounced by experts to be excellent and superior to the average work of the kind furnished in this vicinity. The form of the teeth of the gears was invariably approved. With every change of gears, experts were called in to examine their position and condition. During these experiments the largest gear, which had 46 teeth, was used upon the turbine shaft as crown gear, while the smallest, which had 26 teeth, was on the horizontal or "Jack Shaft." The bearings were kept well oiled, but, as it is a common idea with gear makers that the teeth of gears *roll* together so that they work just as easy when dry as when well lubricated, the first trial was made with dry gears. The table below shows results.

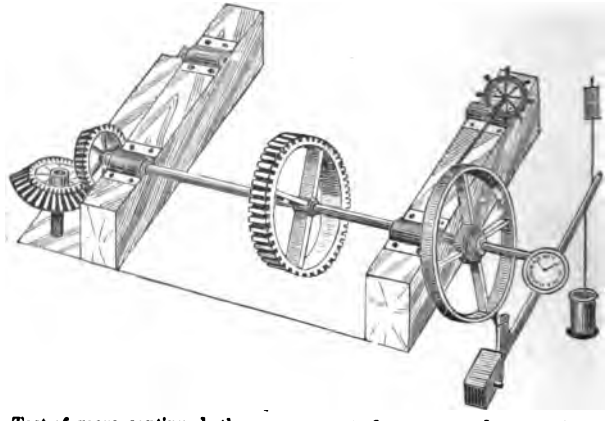
Data below for one minute. Multiply revolutions by 10.

Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
17.96	150	487.5	22.14	1012.14	.6449
17.98	125	611.5	23.16	997.02	.6840
17.96	135	564	23.07	997.02	.6821
17.96	130	565	22.25	993.67	.6601
17.96	120	612	22.25	995.34	.6589

Test through same gears, the gears being thoroughly lubricated.

18.04	150	646	29.36	961.93	.8957
18.04	160	609	29.38	966.94	.8913
18.04	170	558	28.74	978.66	.8619
18.03	180	506	27.60	976.14	.8303
18.05	165	584	29.20	975.31	.8779

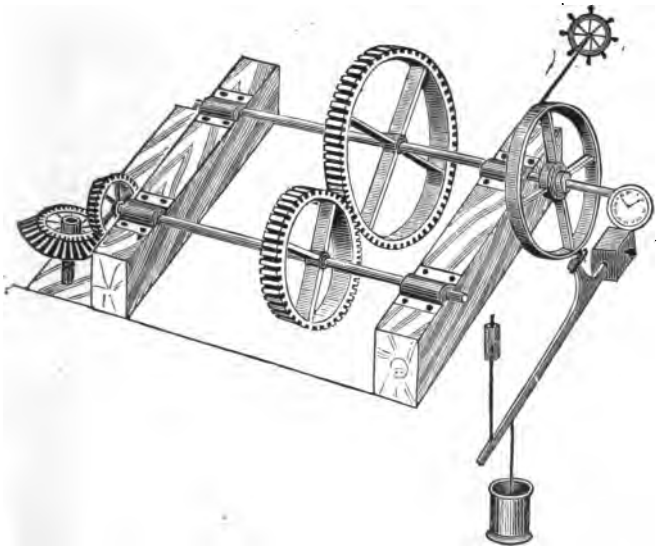
Experiments with Gears.



Test of gears continued, the arrangement of gears named on previous page being reversed, or the small gear having 26 teeth being on turbine shaft, that of 46 teeth on "Jack Shaft"—gears being worked without lubrication of any kind. Data below for one minute. Multiply revolutions by 10.

Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
18.10	210	267.5	17.02	882.34	.5642
18.08	220	261.5	17.43	893.69	.5712
18.07	230	256	17.84	896.95	.5826
18.07	240	253	18.40	898.58	.6000
18.06	250	248.5	18.82	901.84	.6117
18.05	260	245	19.30	910.00	.6221
18.03	270	241	19.71	923.10	.6270
18.03	280	239.2	20.95	926.38	.6650
18.04	290	237.5	20.87	926.38	.6613
18 03	300	230.5	20.95	928.02	.6628
Test of above named arrangement of gears, the gears being well oiled.					
17.83	350	229	24.28	902 45	.7989
17.81	400	221	26 78	937.06	.8494
17.78	425	213	27.43	962.00	.8490
17.77	450	204	27.81	968.68	.8555
17.76	475	196	28.21	972.00	.8653
17.75	500	187	28.33	978.71	.8634
17.74	525	173.5	27.60	798.71	.8416
Verification of the same arrangement of gears taken several days later.					
18.02	475	197.5	28.42	963.56	.8665
18.03	525	176.5	28.07	969.63	.8500
18.02	512.5	180 6	28.04	971.31	.8482
18.05	500	187.8	28.15	973.59	.8571
During the above tests, the teeth of the gears ran rather close together, though perfectly free and were correctly placed according to the opinion of experts in such matters. They were separated about 1-16 in. more, then gave the results below.					
18.02	500	191 5	29.01	972.67	.8762
17.99	510	187.5	28.97	979.33	.8706
18.00	520	184.2	29.02	981.00	.8700

Experiments with Gears.



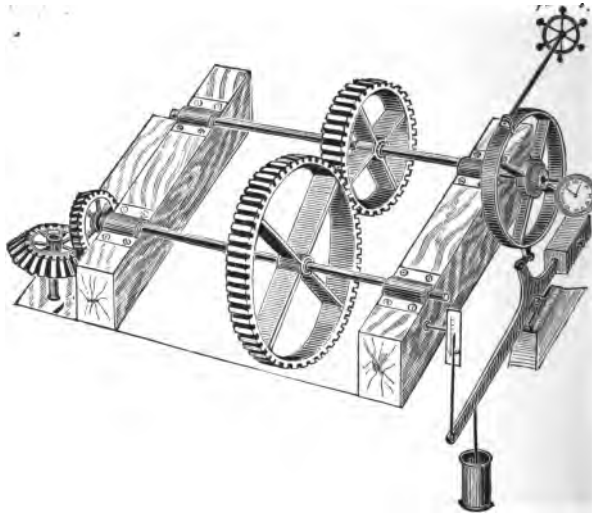
Test of gears continued, a second horizontal shaft being added to the previous arrangement described on foregoing page. This shaft, representing the main line of shafting through a mill, was connected to the "Jack Shaft" by a pair of spur gears—the large one, about 27 inches diameter, 1¾ inches pitch, 5-inch face, having 49 teeth, was secured upon the second horizontal shaft or main line, and was driven by a gear on "Jack Shaft," same face and pitch as the above, and about 16½ inches diameter, having 30 teeth. The brake was placed upon the end of second line, the power of wheel being transmitted through the two pairs of gears, as represented above.

Data below for one minute. Multiply revolutions by 10.

Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
17.94	300	165.5	15.16	841.18	.5319
17.91	350	158.5	16.81	857.35	.5796
17 90	400	151	18.30	870.33	.6234
17.87	500	139	21.06	906 32	.6884
17.85	550	133.5	22.25	934.34	.7064
17.84	600	126.5	23.00	947.63	.7202
17.90	625	125	23.65	939.37	.7443
17 90	675	118	24.13	956.01	.7465
17.94	650	120	23.63	966.03	.7219
17.85	700	109	23.12	964.36	.7112

The gears were thoroughly lubricated with a mixture, used for the same purpose in a mill near by, probably composed of tallow and tar.

Experiments with Gears.



Continuation of the combined spur and bevel gear experiments, the spur gears having been changed, the one having 49 teeth being placed upon the "Jack Shaft" and working into the one having 30 teeth on second horizontal shaft upon which the brake was placed—the small bevel gear being continued as crown gear through all these tests.

Data below for one minute. Multiply revolutions by 10.

Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
17.86	270	310	25.36	972.87	.7727
17.86	285	317.5	25.49	977.28	.7731
17.84	260	323.5	25.52	971.21	.7798
17.84	280	301.5	25.58	978.96	.7755
17.84	290	277.5	24.47	985.61	.7380
17.84	250	326.7	24.75	961.18	.7641
Verification test, taken several days later.					
18.03	275	305.1	25 42	980.22	.7614
Another test of the same arrangement after being taken down, then reset.					
17.66	285	278.5	24.05	972.63	.7409
17.67	275	286.1	23.84	962.70	.7419
17.69	265	304	24.41	964.36	.7576
17.78	270	297.5	24.34	971.00	.7504
17.82	275	296.5	24.41	974 33	.7442
17.86	270	300.5	24.58	971.00	.7504

Belt Experiments.

To prepare for the experiments to determine the loss of power in transmission through belts, the wheel was raised in flume sufficiently to bring top of shaft above upper bearing, to give room for placing a 30-inch pulley thereon; this was done by adding another 10-inch platform to the first.

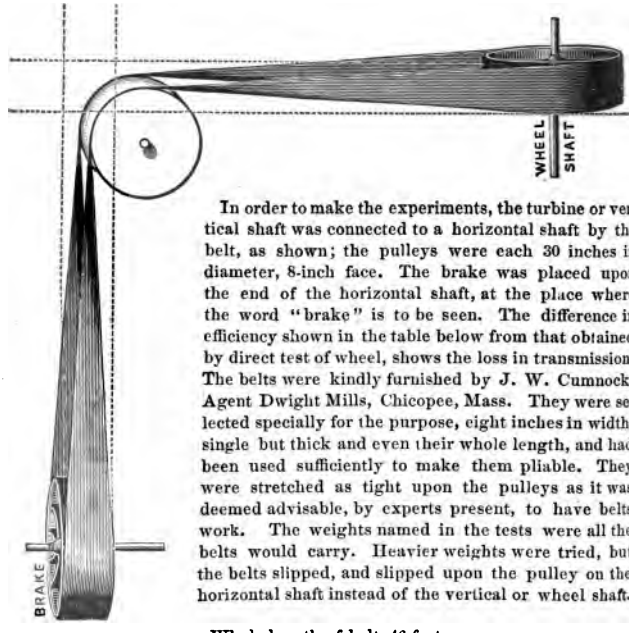
The wheel itself was first tested by placing the brake on the wheel shaft in the usual way. That it did not repeat the efficiency shown previously, was due to alterations made in the conditions. First, the step was altered somewhat in form, then the wheel was placed considerably above the floor of the flume for the purpose named above, and the difference in the head probably effected it; but the conditions, however, continued the same through the belt tests.

Wheel Test.

Data below for one minute. Multiply revolutions of wheel by 10.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	12.03	150	292.5	13 29	735.43	.7954
" "	12.00	170	278.5	14.34	740.05	.8550
" "	11.97	185	270	15.13	760.16	.8804
" "	11.95	200	239	14.48	772.61	.8303
" "	11.94	195	247	14.59	772.61	.8375
" "	11.95	190	262.5	15.11	771.06	.8682
" "	11.96	180	271	14.78	763.27	.8559

Quarter-Turn Belt.



In order to make the experiments, the turbine or vertical shaft was connected to a horizontal shaft by the belt, as shown; the pulleys were each 30 inches in diameter, 8-inch face. The brake was placed upon the end of the horizontal shaft, at the place where the word "brake" is to be seen. The difference in efficiency shown in the table below from that obtained by direct test of wheel, shows the loss in transmission. The belts were kindly furnished by J. W. Cumnock, Agent Dwight Mills, Chicopee, Mass. They were selected specially for the purpose, eight inches in width, single but thick and even their whole length, and had been used sufficiently to make them pliable. They were stretched as tight upon the pulleys as it was deemed advisable, by experts present, to have belts work. The weights named in the tests were all the belts would carry. Heavier weights were tried, but the belts slipped, and slipped upon the pulley on the horizontal shaft instead of the vertical or wheel shaft.

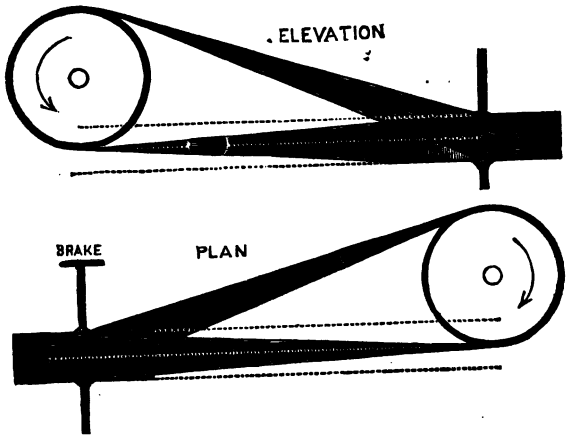
Whole length of belt, 46 feet.

Data below for one minute. Multiply revolutions by 10.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate, ...	12.46	125	303	11.47	794.52	.6134
" "	12.42	135	279.5	11.43	787.66	.6185
" "	12.35	145	256	11.24	787.66	.6116
" "	12.28	155	236.5	11.11	803.96	.5957
" "	12.30	120	300	10.91	783.68	.5992
" "	12.27	130	285.8	11.25	788.24	.6158

Quarter-Twist Belt.

Pulley, 30 inches in diameter; 8-inch face.



Whole length of belt, about 35 feet.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	12.13	100	349.6	10.59	724.86	.6376
" "	12.00	125	319.5	12.10	761.71	.7009
" "	11.98	135	305	12.47	767.73	.7177
" "	11.96	145	295	12.96	775.73	.7396
" "	11.95	155	281.5	13.22	782.00	.7490
" "	11.94	165	268	13.40	783.54	.7584
" "	11.95	175	252	13.30	783.54	.7521

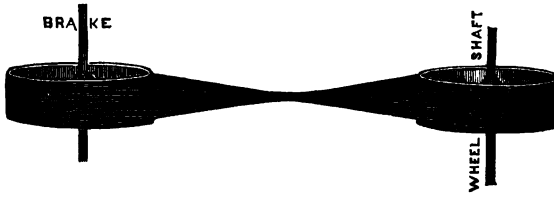
Open Belt.

Whole length of this belt about 36 feet.

Data for one minute. Multiply revolutions by 10.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	12.28	150	324.2	14.73	769.49	.8253
" "	12.11	175	286.2	15.17	785.11	.8447
" "	12.05	190	261.5	14.99	789.81	.8359
" "	11.99	180	273.5	14.92	788.24	.8359
" "	11.98	185	261.5	14.66	788.24	.8220
" "	11.97	170	273.5	14.08	780.36	.7980
" "	11.96	165	289.2	14.47	788.24	.8126

Cross Belt.



Pulleys the same and in the same position as when tried with open belt.

Gate Opened	Head	Weight	Rev per minute	Horse Power	Cubic Feet	Per Cent
Whole Gate.	12.03	150	311	14.13	774.17	.8032
" "	11.99	160	291	14.10	778.85	.7993
" "	11.97	170	271.5	13.98	783.54	.7891
" "	11.96	180	251.5	13.71	788.24	.7700
" "	11.99	140	317	13.45	769.49	.7719

PHENOMENAL TURBINES.

It is here necessary to utter a caution against the selection of a turbine from any make because one of the kind has been reported as giving remarkable results. Mr. Boyden reported in an exceptional case high efficiency, yet the builders of that wheel refuse to guarantee above 75 per cent.; and tests prove many of them to be below that. Stevenson's wheel was reported above 90 per cent. at the Birkinbine, Philadelphia, tests; yet it would now be difficult to find a Stevenson wheel in use. The Risdon, reported so high at the Centennial tests, is little talked of now. The Hercules, reported as giving the highest average results ever obtained from a turbine, often gives less, though remarkably efficient, if care is used in the selection, as may be seen by the results obtained in the trials here reported. The first Wolf wheel tested gave it a reputation that was soon lost by subsequent tests of other, and particularly larger wheels. The same is true of the Walsh. As to the small Victor reported in connection with the gear, belt and draft tube experiments, probably not one in a thousand of that make would repeat those results. Two of the same size since tested, under the same conditions, sent to fill orders, did not reach 80 per cent. in either case. At whole gate the Victor stands unequaled in efficiency, but care is necessary in selection with that as with any other make of turbine, and particularly in the selection of the larger sizes which have not proved so efficient as the smaller ones.

Caution is also necessary in the consideration of the "part gate" claims, published in circulars. It can be a matter of little importance to mill owners whether the gate is one-fourth, one-half, three-fourths or wholly opened, if the same quantity of water is discharged in either case. Many of the turbine gates may be closed one-half without diminishing the discharge materially. The gate of a 36-inch Swain turbine raised four inches as its maximum. With one inch of that opening, it discharged three-fifths of the whole quantity. In a circular before me, the builder states that his wheel gives 70 per cent. at three-eighths gate. The report of the test is published therewith. The whole-gate discharge is 2300 cubic feet per minute, while the discharge at his three-eighths gate is over 1600 cubic feet per minute.

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